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RCRA Facility Investigation Report for the 200-PO-1 Operable Unit

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ACRONYMS

AAMSR	Aggregate Area Management Study Report
AKART	all known, available, and reasonable technologies
AWQC	Ambient Water Quality Criteria
BAT	best available technology
BWIP	Basalt Waste Isolation Project
CFR	Code of Federal Regulations
CMS	corrective measure study
COPC	contaminant of potential concern
DCG	Derived Concentration Guides
DOE	U.S. Department of Energy
DQO	data quality objective
Ecology	Washington Department of Ecology
EPA	U.S. Environmental Protection Agency
ERA	environmental risk assessment
HRM	Hanford river miles
HVAC	heating, ventilation, and air conditioning
IRM	interim remedial measure
LFI	limited field investigation
MCL	maximum contaminant level
MTCA	Model Toxic Control Act
NRDWL	Nonradioactive Dangerous Waste Landfill
OEMP	Operational Environmental Monitoring Program
PNL	Pacific Northwest Laboratories
RCRA	Resource Conservation and Recovery Act
RFI	RCRA facility investigation
TEDF	Treated Effluent Disposal Facility
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
TSD	treatment, storage, and disposal
WAC	Washington Administrative Code
WDOH	Washington State Department of Health
WHC	Westinghouse Hanford Company
WIDS	Waste Information Data System

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) report is prepared in support of the RFI/Corrective Measures Study (CMS) process for the 200-PO-1 Groundwater Operable Unit in the 200 East Area of the Hanford Site (Figure 1-1). This document has been prepared in lieu of an RFI/CMS work plan since U.S. Environmental Protection Agency (EPA), Washington Department of Ecology (Ecology), and the U.S. Department of Energy (DOE) agree that sufficient data are currently available to prepare the RFI report and that additional data gathering activities are not warranted at this time. In addition, the parties agree that sufficient existing information, as reported in this RFI, or in-process information, such as the iodine-129 study being conducted under Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) Milestone, M-15-81b, would be available to support the development and evaluation of corrective measures performed during future development of a CMS report.

1.2 DATA QUALITY OBJECTIVES PROCESS

The original scope of work identified by Tri-Party Agreement Milestone M-13-10 was to prepare an RFI/CMS work plan. A significant part of this scope was a data quality objectives (DQO) process to help facilitate the design and preparation of a field investigation. During the course of the DQO process, DOE and the regulators determined that existing information was sufficient to support preparation of an RFI report and that additional data collection was not required. Therefore, the major decision from the DQO process was to eliminate the milestone for the RFI/CMS work plan and to incorporate the following milestones into the Tri-Party Agreement:

> M-15-25: Submit a draft RFI report to DOE, EPA, and Ecology for concurrent review by December 31, 1995.
>
> M-15-25A: Submit a draft CMS report to DOE, EPA, and Ecology for concurrent review by July 31, 1996.
>
> M-15-25B: Submit the documentation to include the operable unit in the RCRA permit modification process.

The DQO process is summarized in Appendix A. Additional information concerning the DQO process is included in the project files.

1.3 OPERABLE UNIT DEFINITION

The 200-PO-1 Operable Unit is bound by the 2,000 pCi/L tritium contamination plume contour as it extends eastward and southward from the source(s) located at the southern portion of the

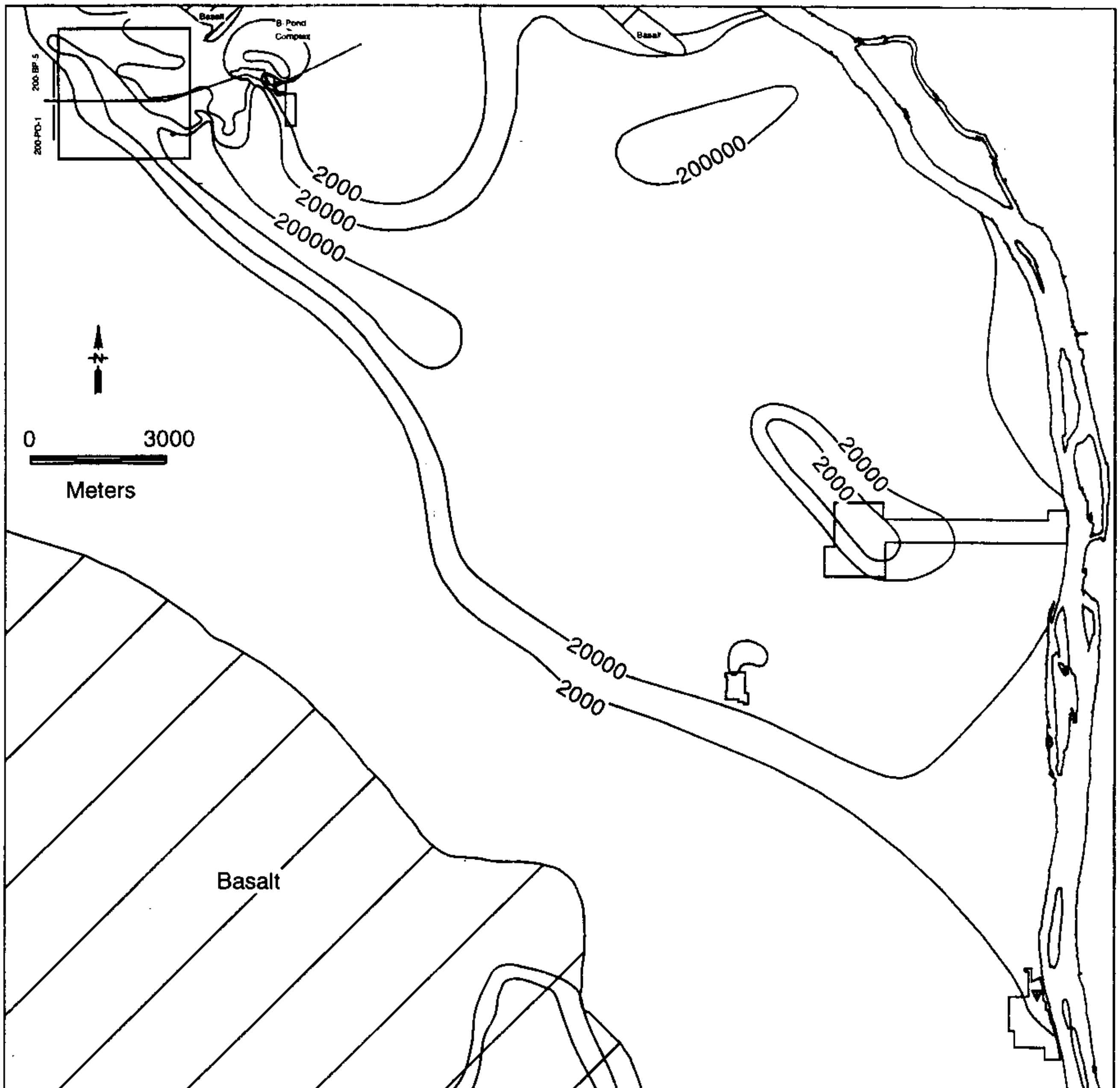
200 East Area. The eastern boundary is the Columbia River. The southern boundary is adjacent to the 300-FF-5 Operable Unit boundary and does not extend south of the 399-1-18 A, B, and C well cluster (Figure 1-1). The operable unit is bound on the north by the 200-BP-5 Groundwater Operable Unit.

1.4 REPORT ORGANIZATION

This report summarizes existing information on this operable unit presented in the 200 East and PUREX Aggregate Area Management Study Reports (DOE-RL 1992a and DOE-RL 1992b), contaminant specific studies, available modeling data, and groundwater monitoring data summary reports. Existing contaminant data are screened against current regulatory limit (e.g., Federal maximum contaminant level [MCL], Model Toxic Control Act [MTCA] - B, etc.) to determine contaminants of potential concern (COPC). Each identified COPC is evaluated using well specific and plume trend analyses. The report concludes with an assessment of existing groundwater monitoring networks for adequacy in monitoring 200-PO-1 groundwater plumes. The report is organized in the following sections:

- Section 1.0 is an introduction to the RFI report
- Section 2.0 is a summary of existing information
- Section 3.0 is a summary of the conceptual model for the operable unit
- Section 4.0 is a summary of the nature and extent of contamination
- Section 5.0 is a summary of future activities.
- Appendix A is a summary of the DQO process and results
- Appendix B is a summary of geologic cross sections.

Figure 1-1. 200-PO-1 Operable Unit Boundary (as defined by the 2,000 pCi/L tritium contour)



200-PO-1 Operable Unit Boundary as Defined by the Extent of Tritium Groundwater Contamination

Tritium isopleths are based on averaged result values for 1994.
Units are picoCuries-per-liter (pCi/L).

2.0 OPERABLE UNIT INVESTIGATIONS

Groundwater beneath the 200 East Area and eastward to the Columbia River has been sampled over the past several years primarily through the following three monitoring programs:

- Operational Environmental Monitoring Program
- Hanford Groundwater Environmental Surveillance Program
- RCRA Groundwater Monitoring.

These primary sources of operable unit-specific information are the basis for the definition of operable unit characteristics and determination of groundwater contaminants presented in subsequent sections of this report. The following sections summarize existing data collection activities associated with the groundwater monitoring programs mentioned above, as well as pertinent information presented in the *200 East Area Groundwater Aggregate Area Management Study Report* (AAMSR) (DOE-RL 1992a).

2.1 200 EAST AREA GROUNDWATER AGGREGATE AREA MANAGEMENT STUDY REPORT

The primary supporting document for this RFI report is the 200 East Groundwater AAMSR (DOE-RL 1992a). The purpose of the AAMSR was to compile and evaluate the existing knowledge of the 200 East Area groundwater to support the *Hanford Past-Practice Strategy* (DOE-RL 1991) decision making process. Under the *Hanford Past-Practice Strategy* (DOE-RL 1991), groundwater contaminants/plumes were recommended to be addressed under one of four paths (i.e., expedited response action [ERA], interim remedial measure [IRM], limited field investigation [LFI], or final remediation).

The AAMSR presents a comprehensive evaluation of 200-PO-1 contaminants and contaminant sources. This information along with current groundwater sampling provides sufficient information for the determination of the nature and extent of contamination discussed in Section 4.0 of this report.

2.2 OPERATIONAL ENVIRONMENTAL MONITORING PROGRAM

The Operational Environmental Monitoring Program (OEMP) administered by Westinghouse Hanford Company (WHC) assesses and monitors the impacts of nuclear processing facilities and radiological waste sites on the local environment. The monitoring activities on the Hanford Site include sampling and analysis of ambient air, surface water, groundwater, sediments, soil, and biota. The analyses are primarily for radioactive constituents (i.e., gross alpha, gamma, strontium-90, technetium-99, iodine-129, hydrogen-3, total uranium, and plutonium-238/239/240), however, other nonradioactive parameters such as pH, nitrate, and temperature are also recorded (DOE-RL 1994a).

The objectives of the OEMP are to evaluate the following:

- compliance with DOE, EPA, Ecology, Washington State Department of Health (WDOH) and internal WHC radiation protection requirements and guidelines
- performance of radioactive waste containment systems
- trends of radioactive materials in the environment at, and adjacent to, nuclear facilities and waste disposal sites.

Specific objectives of the groundwater monitoring program are to:

- comply with interim and final status State and Federal RCRA requirements to assess potential or groundwater quality
- determine the impact of waste disposal operations on the groundwater to provide an early warning of unusual occurrences and trends
- assess the performance of disposal and storage sites on the Hanford Site
- provide data for hydrologic analysis and model allocation.

Wells are sampled monthly, quarterly, or semiannually, depending on the operating history and/or level of and rate of change in contamination in a given area. The OEMP wells are shown in Figure 2-1. Table 2-1 lists the analytes sampled for during monitoring.

2.3 SITE-WIDE ENVIRONMENTAL MONITORING

Site-wide environmental monitoring at the Hanford Site is performed by Pacific Northwest Laboratories (PNL) to assess potential environmental and human health impacts due to Hanford Site contaminants. The environmental surveillance program includes sampling and analysis for potential radiological and chemical contaminants on and off the Hanford Site. The primary objectives for the annual surveillance program are to:

- verify compliance with DOE and EPA radiological dose standards for public protection
- assess adequacy of facility pollution controls
- assess the environmental and public health impacts of Hanford operations
- identify and quantify potential environmental quality problems
- provide information to DOE for environmental management of the Hanford Site, and for the public and regulatory agencies.

Samples are collected as part of the Hanford Groundwater Environmental Surveillance Program, as well as other monitoring programs. The monitoring network wells are shown on Figure 2-2. Table 2-2 lists the analytes sampled for during monitoring.

2.4 RCRA GROUNDWATER MONITORING PROGRAM

The RCRA groundwater monitoring programs are implemented for each RCRA facility on the Hanford Site. The monitoring program is established to assess impacts on the groundwater from each RCRA TSD unit. Title 40 Code of Federal Regulations (CFR) 265.92 establishes groundwater monitoring requirements for RCRA Treatment, Storage and Disposal (TSD) units operating under interim status. Contamination indicator parameters are specified in 40 CFR 265.92(b)(3). The groundwater quality parameters are established in 40 CFR 265.92(b)(2). Parameters used to characterize the suitability of the groundwater as a drinking water supply are specified in Appendix III of 40 CFR 265. In addition, site-specific analytical parameters are determined from review of the waste stream (or source) associated with each RCRA facility.

The 200-PO-1 Operable Unit contains the following RCRA TSD units:

- A-AX Tank Farms
- 216-A-10 Crib
- 216-A-36B Crib
- 216-A-29 Ditch
- 2101-M Pond
- a portion of the 216-B-3 Pond System
- Nonradioactive Dangerous Waste Landfill (NRDWL).

The following sections introduce each facility and identify the monitoring wells and list of analytes supporting the RCRA monitoring program. More detailed information on each RCRA facility is provided in DOE-RL (1994b).

A-AX Tank Farms. The single shell tanks were decommissioned in 1980, but continue to store hazardous and radioactive waste. The tanks are underground reinforced concrete structures with a single liner of carbon steel.

The single shell tanks received mixtures of organic and inorganic liquids containing radionuclides, solvents, and metals that were originally discharged to the tanks as alkaline slurries. The single shell tank wastes consist mostly of salt cake and sludge, but with small quantities of supernate and interstitial liquids that could not be removed during pumping of the liquid wastes into the double shell tanks. The waste is largely inorganic and consists primarily of sodium hydroxide, and sodium salts of nitrate, nitrite, carbonate, aluminate, and phosphate. Some hydrous oxides of iron and manganese also are present. Radionuclides such as cesium-137, strontium-90, technetium-99, uranium, thorium, plutonium, and neptunium constitute the primary radionuclide inventory.

Groundwater has been monitored at the A-AX tank farms since 1989. The monitoring well network is shown in Figure 2-3. The wells are listed in Table 2-3 along with sampling frequency, well construction type and coordination with other monitoring networks. Table 2-4 identifies the analytes sampled at the A-AX Tank Farms. More detailed information on the single shell tanks is available in DOE-RL (1994b).

216-A-10 Crib. This crib is an inactive facility which was previously used for the disposal of liquid waste from PUREX. Discharge was direct to the soil column approximately 97 m (318 ft) above the water table. The crib was operational in 1956, 1961-1973, 1977, 1978, 1981, and 1982-1987. The crib was taken out of service in 1987 and replaced by the 216-A-45 crib (DOE-RL 1994b).

The discharges to the crib were characteristically acidic and contained concentrated salts. Other waste streams included:

- aliphatic hydrocarbon compounds
- organic complexants
- radionuclides (i.e., plutonium, uranium, strontium-90, cobalt-60, cesium-134, ruthenium-103, ruthenium-106, and tritium (DOE-RL 1994b).

Groundwater monitoring has been ongoing at 216-A-10 since 1988. The monitoring wells are identified on Figure 2-4. The wells are listed in Table 2-5 along with sampling frequency, well construction type, and coordination with other sampling networks. Table 2-6 identifies the analytical parameters sampled for at 216-A-10. More detailed information on 216-A-10 is available in DOE-RL (1994b).

216-A-36B Crib. This crib is an inactive facility which was previously used for the disposal of liquid waste from PUREX. Discharge was direct to the soil column approximately 97 m (318 ft) above the water table. The crib received waste from 1965-1972 and 1982-1987. The crib was taken out of service in 1987 (DOE-RL 1994b).

Waste disposed of in the crib include ammonia scrubber distillate consisting of condensate from nuclear fuel decladding operations in which zirconium cladding was removed from irradiated fuel by boiling in a solution of ammonium fluoride and ammonium nitrate. Other potential contaminants included tritium, strontium-90, cesium-137, ruthenium-106, cobalt-60, and uranium.

Groundwater monitoring has been ongoing at 216-A-36B since 1988. The monitoring well network is shown in Figure 2-5. The wells are listed in Table 2-7 along with sampling frequency, well construction type and coordination with other monitoring networks. Table 2-8 identifies the analytes sampled for at 216-A-36B. More detailed information on 216-A-36B is available in DOE-RL (1994b).

216-A-29 Ditch. This ditch is an inactive facility which was previously used as an unlined percolation trench that received liquid effluent from the PUREX chemical sewer line and conducted it to the 216-B-3 Pond system (B-Ponds). Discharges to the ditch were approximately 83 m to 61.5 m (272.5 ft to 202 ft) above the water table depending on location along the ditch. The ditch received waste from 1955-1991 when discharges were eliminated and rerouted to the cooling water line (DOE-RL 1994b). The ditch has been stabilized through the decontamination and decommissioning program.

Waste disposed to the ditch included:

- sodium hydroxide
- sulfuric acid
- corrosive waste
- other hazardous wastes (e.g., hydrazine).

Groundwater monitoring has been ongoing at 216-A-29 since 1988. The monitoring well network is shown in Figure 2-6. The wells are listed in Table 2-9 along with sampling frequency, well construction type and coordination with other monitoring networks. Table 2-10 identifies the analytes sampled for at the 216-A-29 ditch. More detailed information on 216-A-29 is available in DOE-RL (1994b).

2101-M Pond. The pond is a U-shaped unlined trench which received wastewater from the 2101-M Building heating and air conditioning system since 1953, as well as Basalt Waste Isolation Project (BWIP) laboratory waste from 1981 to 1982.

Wastes potentially disposed of at the site include:

- copper - from heating, ventilation, and air conditioning (HVAC) piping
- barium chloride
- hydrochloric and nitric acid
- selenium
- chromium.

Groundwater monitoring has been ongoing at the 2101-M Pond since 1989. The monitoring well network is shown in Figure 2-7. The wells are listed in Table 2-11 along with sampling frequency, well construction type, and coordination with other monitoring networks. Table 2-12 identifies the analytes sampled for at 2101-M. More detailed information on the 2101-M Pond is available in DOE-RL (1994b).

216-B-3 Pond System. The B-Pond system is a RCRA-regulated disposal unit for 200 East operations. The pond system consists of a main pond, three interconnected lobes (B-3-1, B-3-2, and B-3-3), and three ditches extending east from the 200 East Area fenceline. The main pond began receiving liquid waste in 1945 and the expansion lobes (A, B, C) were put into service in 1983, 1984, and 1985, respectively.

The pond system received wastewater from B-Plant cooling water, PUREX plant chemical sewage, PUREX plant steam condensate, 242-A Evaporator (cooling water and steam condensate), 244 AR vault (liquid effluent) 241-A-702 vessel ventilation system (cooling water), 283-E Water Treatment Facility (filter backwash), and 284-E Powerhouse (liquid effluent). Potential contaminants which may have been disposed are discussed in the closure plan for the ponds (DOE-RL 1993a).

Groundwater monitoring has been ongoing at 216-B-3 since 1988. The monitoring well network is shown in Figure 2-8. The wells are listed on Table 2-13 along with sampling frequency, well construction type, and coordination with other monitoring networks. Table 2-14 lists the analytes sampled for at the 216-B-3 pond complex. More detailed information on 216-B-3 is available in DOE-RL (1994b).

Nonradioactive Dangerous Waste Landfill. The NRDWL is an inactive dangerous waste landfill which received nonradioactive dangerous wastes from 1975 to 1985. The NRDWL continued to receive asbestos waste until 1988 (DOE-RL 1994b).

Groundwater monitoring has been ongoing at NRDWL since 1986. The monitoring well locations are shown on Figure 2-9. The wells are listed in Table 2-15 along with sampling frequency, well construction type, and coordination with other monitoring networks. Table 2-16 identifies the analytes sampled for at NRDWL. More detailed information on NRDWL is available in DOE-RL (1994b).

Figure 2-1. Operational Environmental Monitoring Program Monitoring Well Network

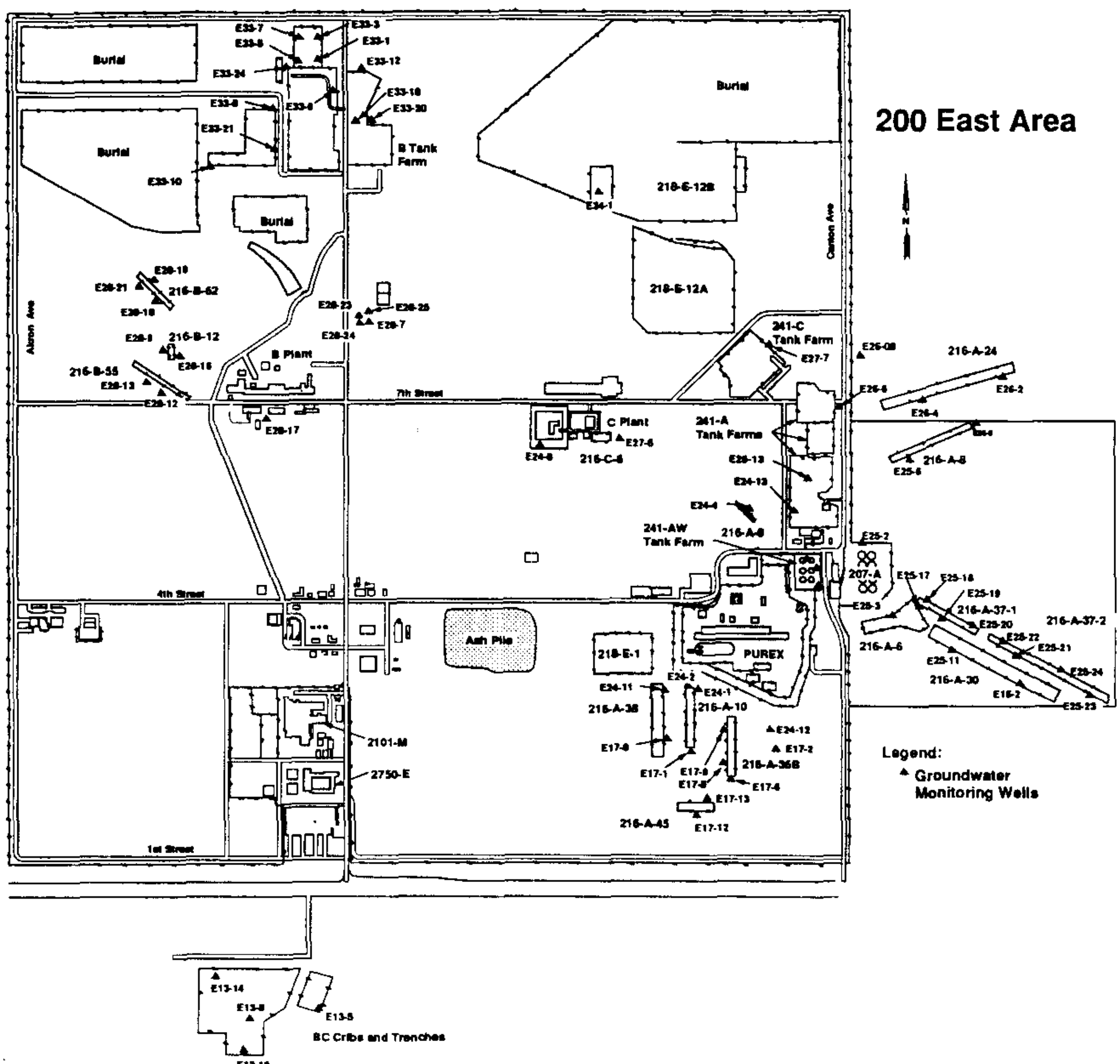
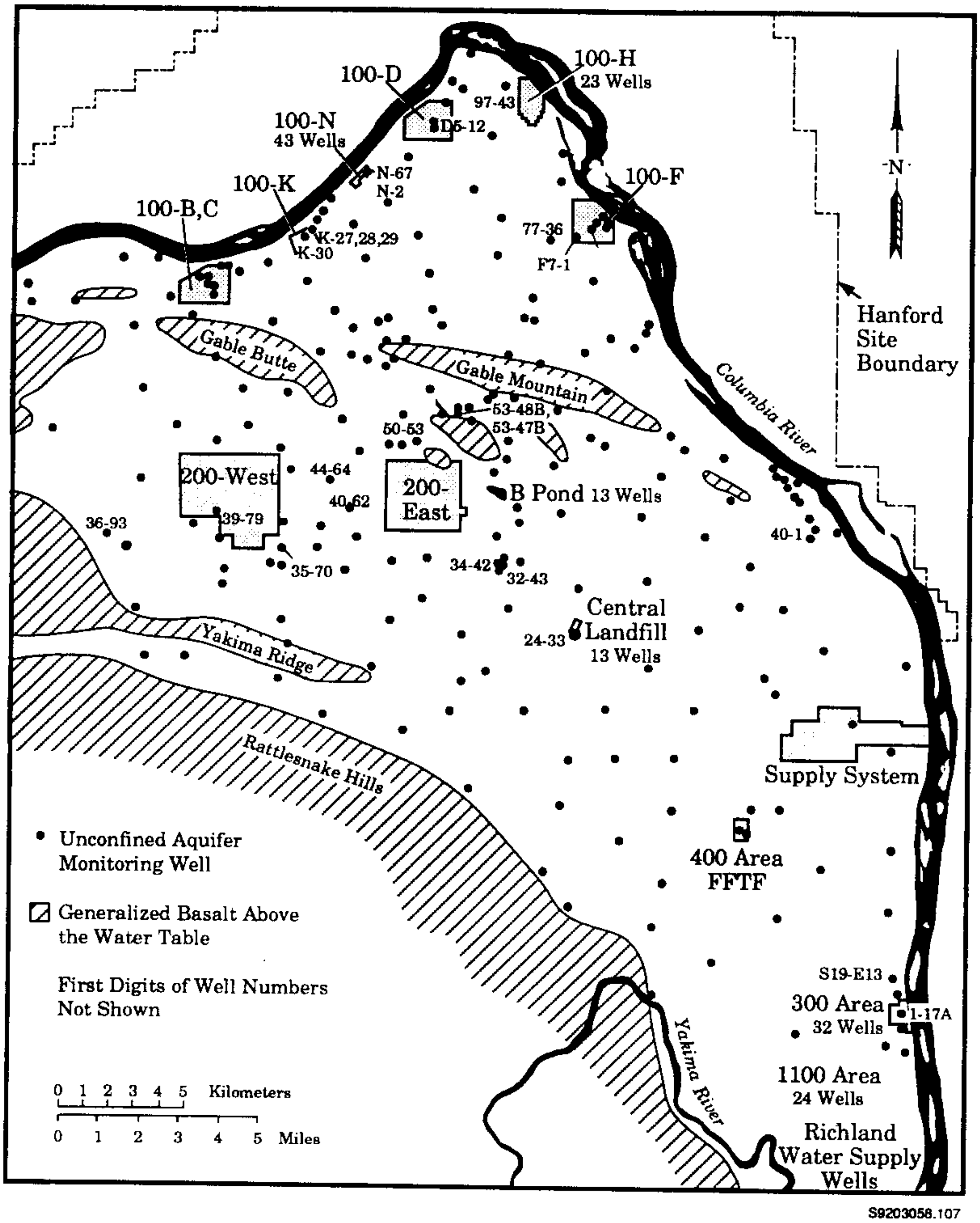


Figure 2-2. Hanford Groundwater Environmental Surveillance Network



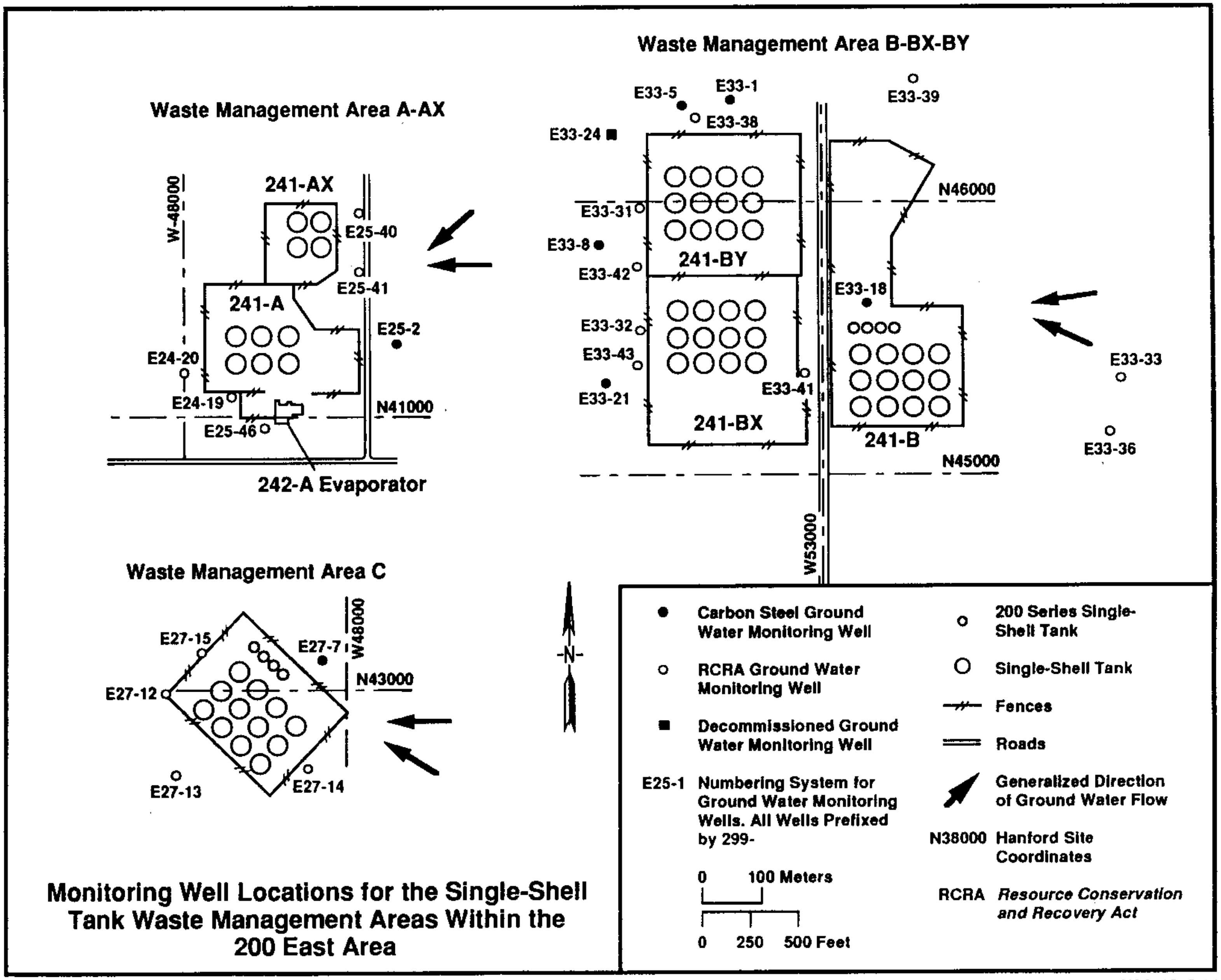


Figure 2-3. A-AX Tank Farm Monitoring Well Locations

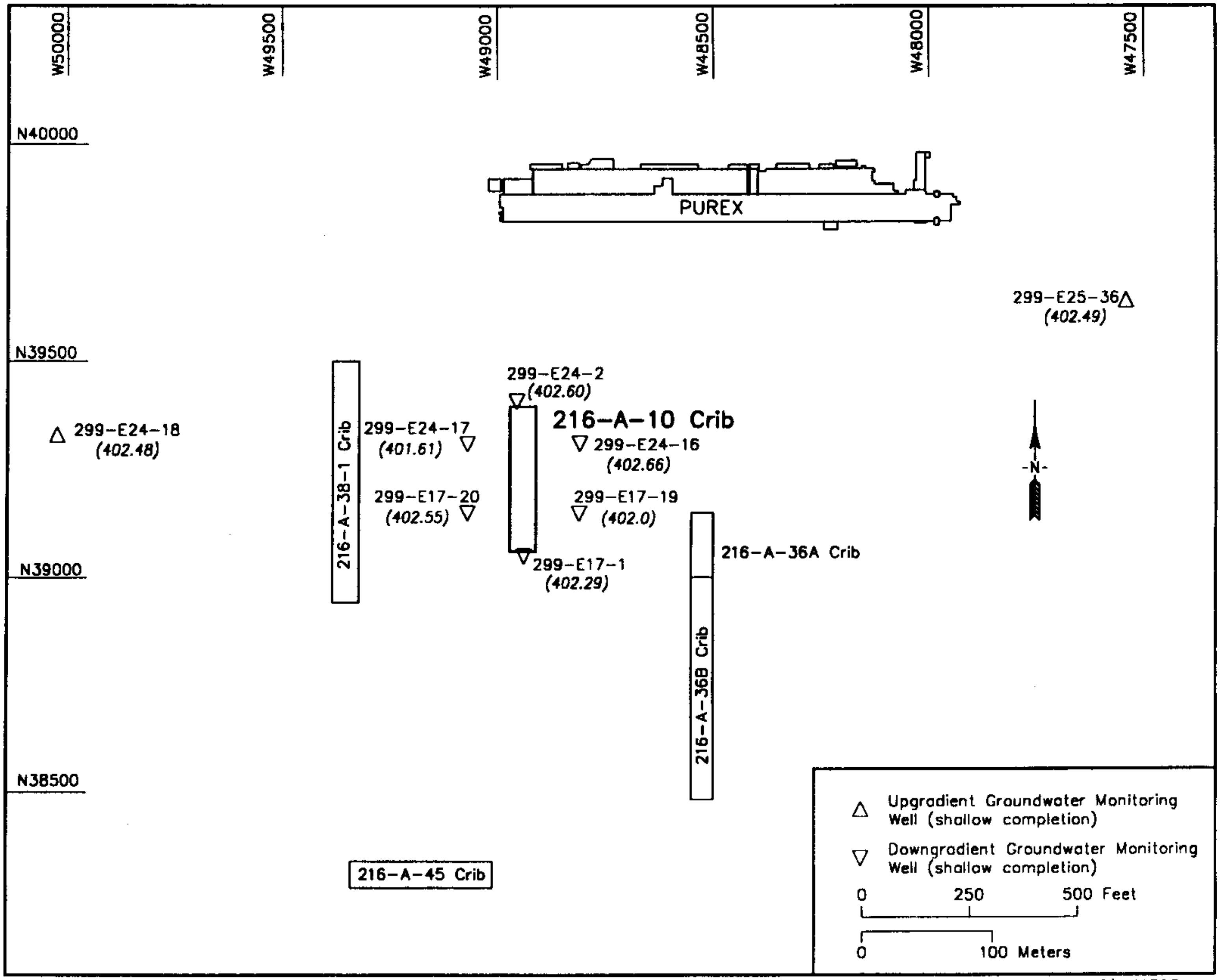


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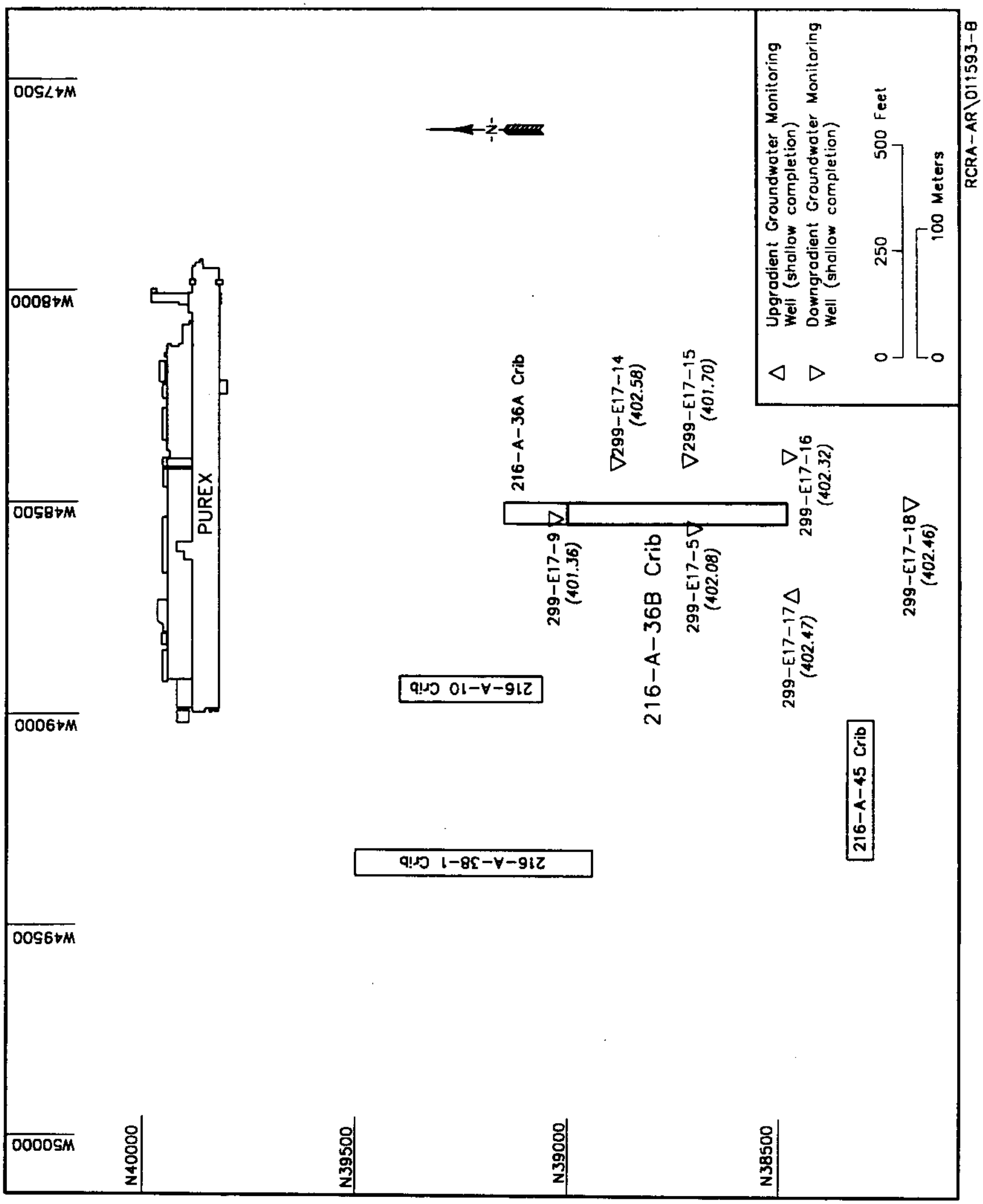
Figure 2-4. 216-A-10 Crib Monitoring Well Locations

Figure 2-5. 216-A-36B Crib Monitoring Well Locations



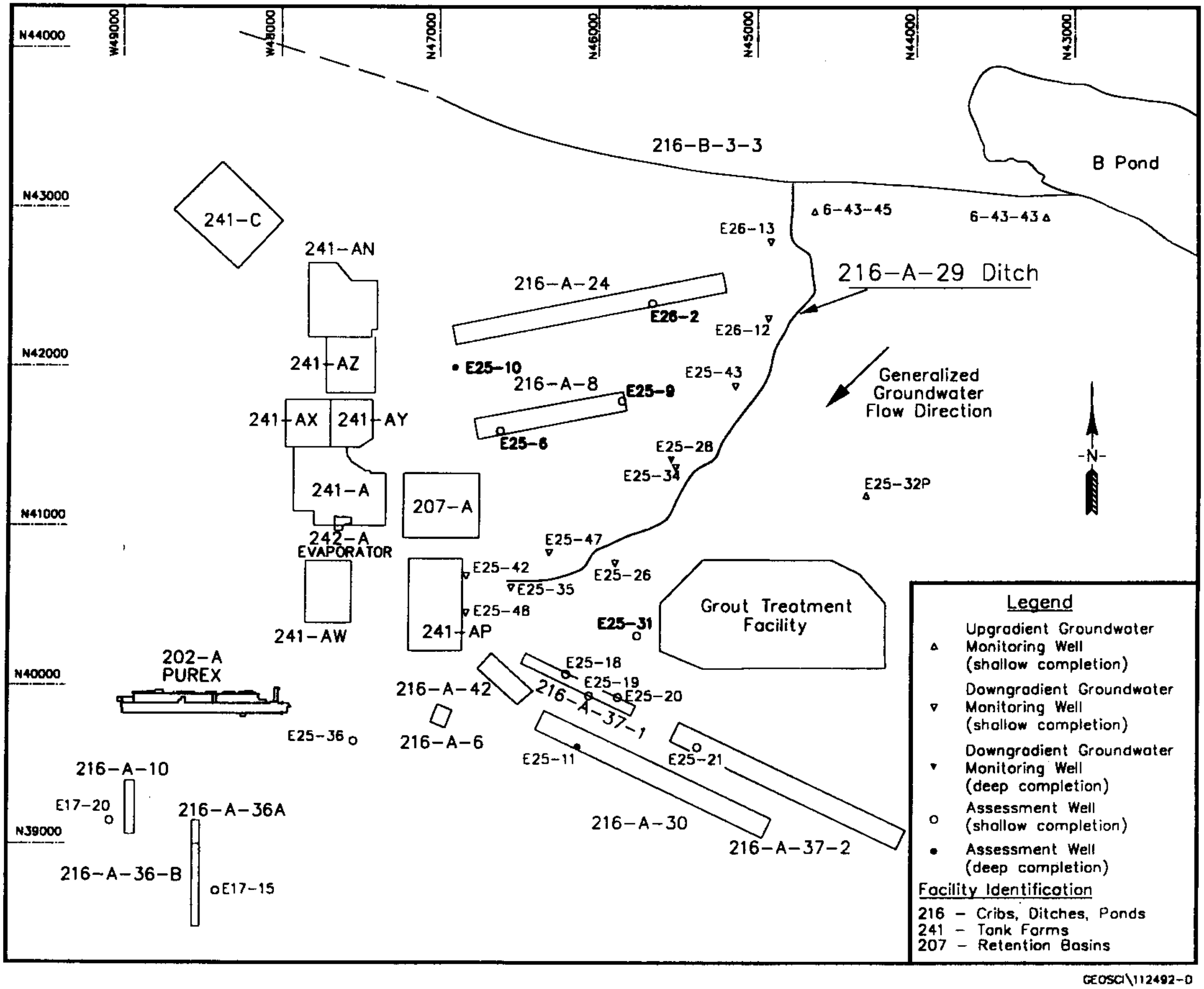
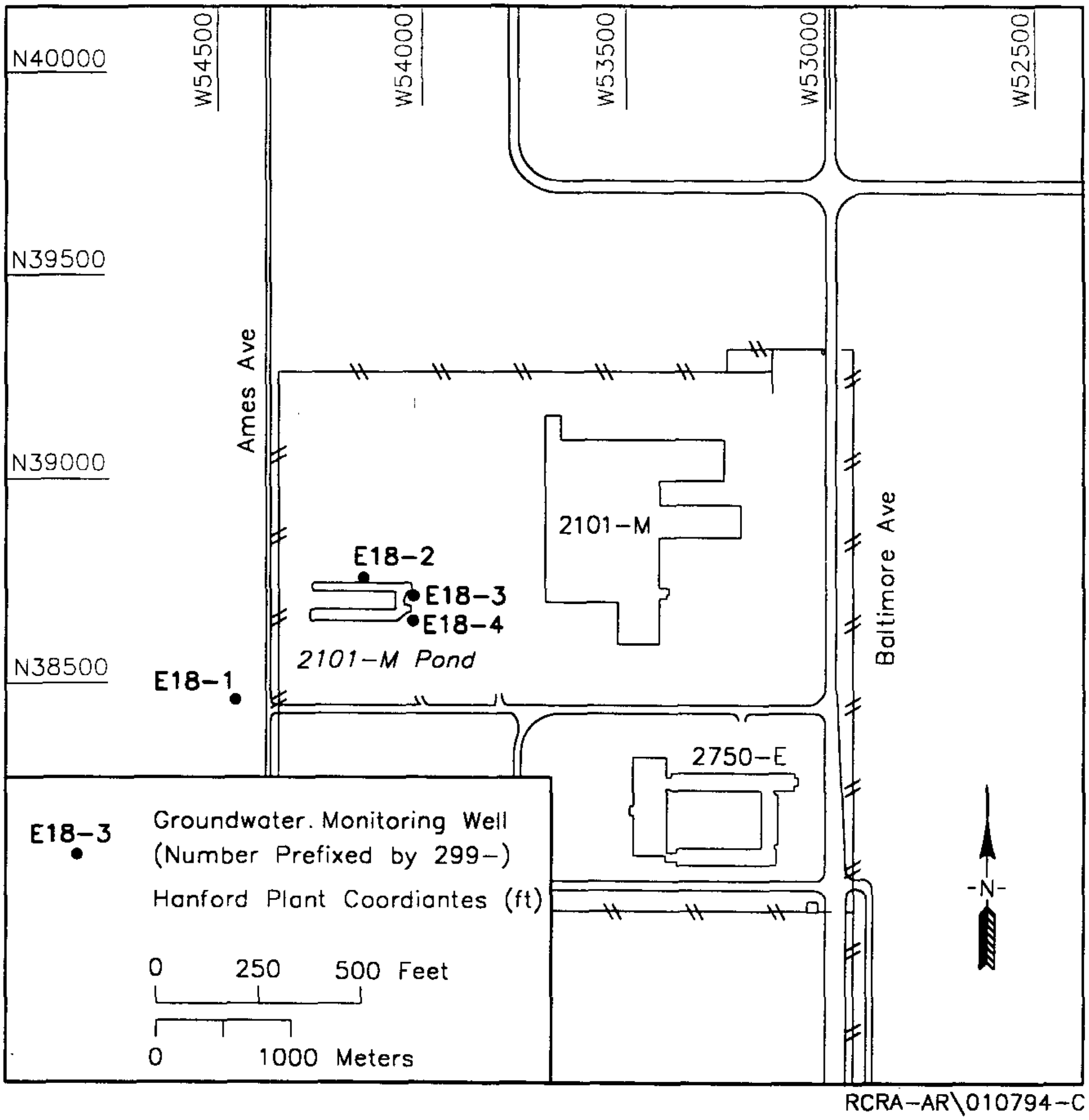


Figure 2-6. 216-A-29 Ditch Monitoring Well Locations

Figure 2-7. 2101-M Pond Monitoring Well Locations



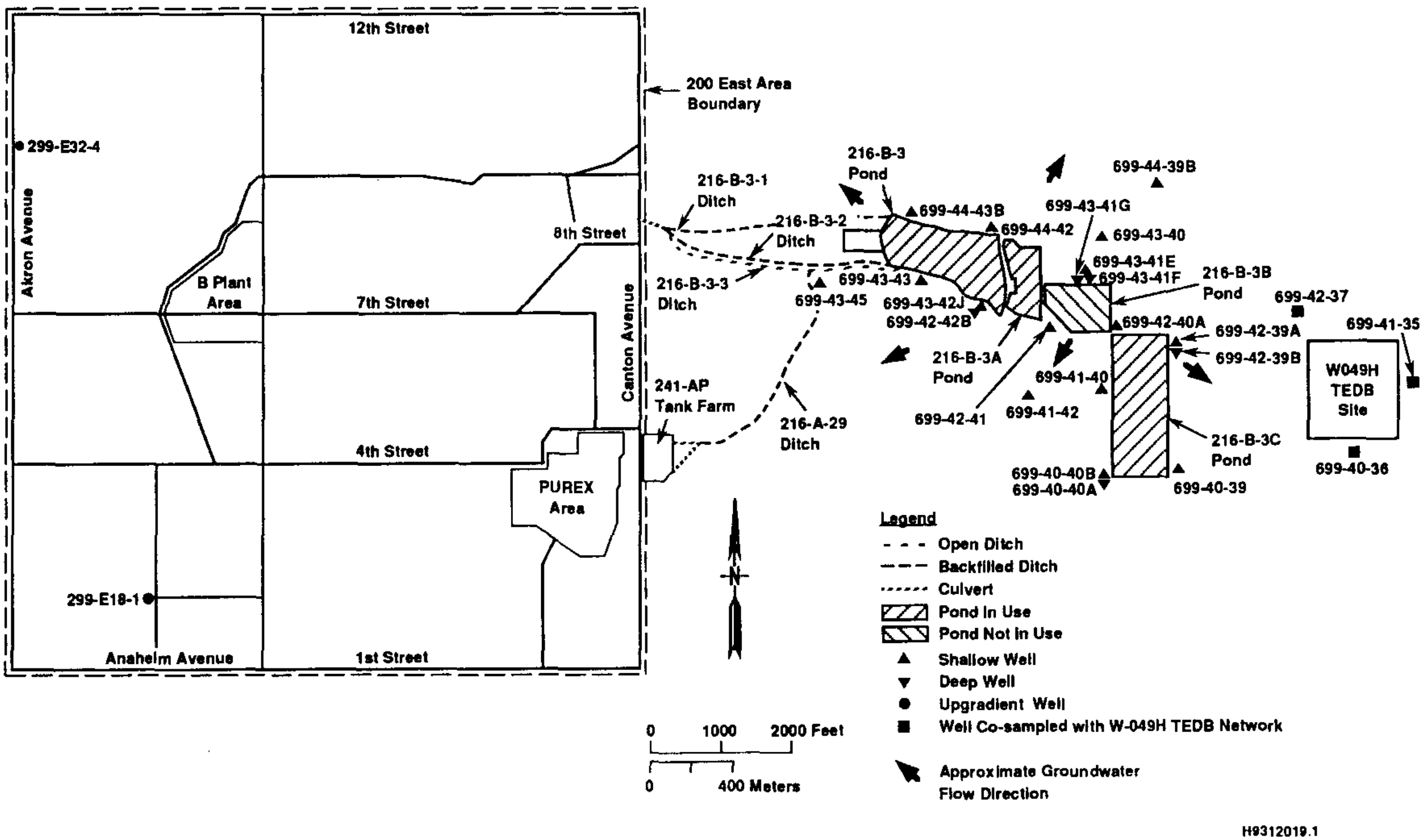


Figure 2-8. 216-B-3 Pond System Monitoring Well Locations

Figure 2-9. Nonradioactive Dangerous Waste Landfill Monitoring Well Locations

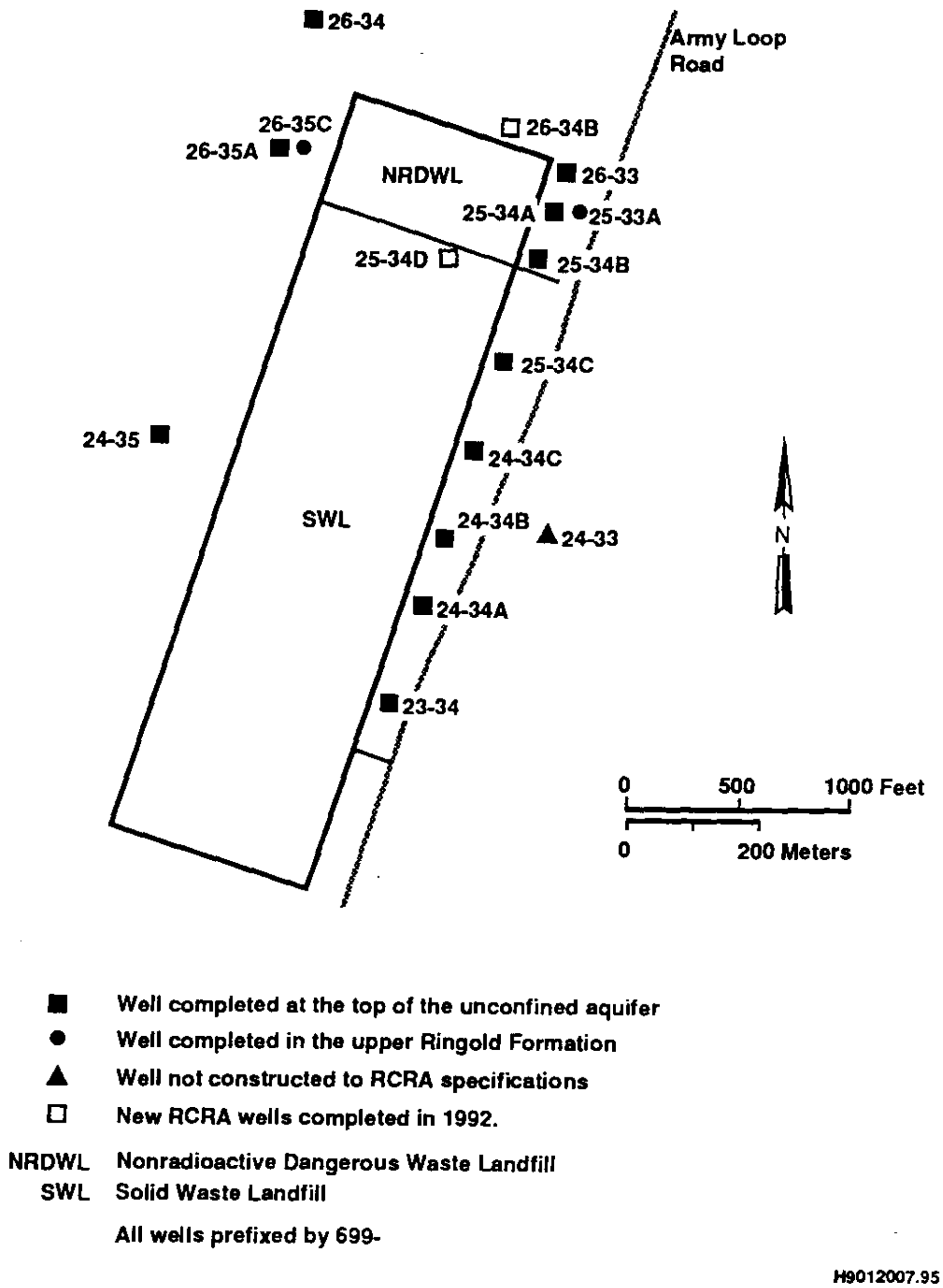


Table 2-1. Operational Environmental Monitoring Program Analytes

Radiological Parameters	Chemical Parameters
gross alpha	pH
gamma	nitrate
strontium-90	temperature
technetium-99	
iodine-129	
tritium	
total uranium	
plutonium-238/239/240	

Table 2-2. Hanford Groundwater Surveillance Analytes

Radiological Parameters	Chemical Parameters
hydrogen-3	pH (field and laboratory)
cobalt-60	conductance (field)
strontium-90	Alkalinity
technetium-99	Total Carbon
ruthenium-103	Total Organic Carbon
ruthenium-106	Total Organic Halogens
antimony-125	boron, beryllium, sodium, magnesium,
iodine-129	aluminum, potassium, cobalt, silicon
iodine-131	calcium, vanadium, chromium, manganese,
cesium-137	iron, nickel
americium-241	copper, zinc, strontium, silver, cadmium,
Total Alpha	antimony, barium
Total Beta	F^-, Cl^-, NO^-_3, PO^{-3}_4, SO^{-2}_4, NO^-_2
Plutonium Isotopes	arsenic, selenium, lead, thallium
Uranium Isotopes	mercury
Uranium (total)	CN^-
	NH_3
	Volatile Organic Constituents
	Semi-Volatile Organic Constituents

Table 2-3. A-AX Tank Farm Monitoring Well Summary

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
299-E24-19[89]	Top of unconfined	S	M	RCRA	--
299-E24-20[91]	Top of unconfined	S	M	RCRA	--
299-E25-40[89]	Top of unconfined	S	M	RCRA	--
299-E25-2[55]	Top of unconfined	--	M	PRE	--
299-E25-41[89]	Top of unconfined	S	M	RCRA	--
299-E25-46[92]	Top of unconfined	S	M	RCRA	--

Notes: Superscript number following well number denotes the year of installation.
M = sampled or measured on a monthly basis.
RCRA = well is constructed to RCRA-specified standards.

Table 2-4. A-AX Tank Farm Groundwater Analytes

Contamination indicator parameters		
pH	Total organic carbon	
Specific conductance	Total organic halogen	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
2,4-D	Endrin	Methoxychlor
2,4,5-TP Silvex	Fluoride	Nitrate
Arsenic	Gross alpha	Radium
Barium	Gross beta	Selenium
Cadmium	Lead	Silver
Chromium	Lindane	Toxaphene
Coliform bacteria	Mercury	Turbidity
Site-specific parameters		
Ammonium	Gamma scan	Strontium-90
Total organics	Iodine-129	Uranium
Cesium-137	Plutonium	Tritium
Cobalt-60		

Table 2-5. 216-A-10 Crib Monitoring Well Summary

Well	Aquifer	Sampling Frequency	Water Levels	Well Standard	Other Networks
299-E 24-18[88]	Top of unconfined	S	Q	RCRA	--
299-E 25-36[88]	Top of unconfined	Q	Q	RCRA	216-A-29
299-E 17-19[88]	Top of unconfined	S	Q	RCRA	--
299-E 17-20[88]	Top of unconfined	Q	Q	RCRA	216-A-29
299-E 24-16[88]	Top of unconfined	S	Q	RCRA	--
299-E 24-17[88]	Top of unconfined	S	Q	RCRA	--
299-E 17-1[55]	Top of unconfined	S	Q	PRE	--
299-E 24-2[56]	Top of unconfined	S	Q	PRE	--

Notes: Superscript following well number denotes the year of installation.
PRE = well was constructed before RCRA-specified standards.
Q = frequency on a quarterly basis.
RCRA = well is constructed to RCRA-specified standards.
S = frequency on a semiannual basis.

Table 2-6. 216-A-10 Crib Groundwater Analytes

Contamination indicator parameters		
pH	Total organic carbon	
Specific conductance	Total organic halogen	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
2,4-D	Endrin	Methoxychlor
2,4,5-TP Silvex	Fluoride	Nitrate
Arsenic	Gross alpha	Radium
Barium	Gross beta	Selenium
Cadmium	Lead	Silver
Chromium	Lindane	Toxaphene
Coliform bacteria	Mercury	Turbidity
Site-specific parameters		
1-butynol	Monobutyl phosphate	Tritium
Dibutyl phosphate	Tetrahydrofuran	Uranium
Gamma scan	Tributyl phosphate	

Table 2-7. 216-A-36B Crib Monitoring Well Summary

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
299-E17-16^{88}	Top of unconfined	S	Q	RCRA	--
299-E17-17^{88}	Top of unconfined	S	Q	RCRA	--
299-E17-18^{88}	Top of unconfined	S	Q	RCRA	--
299-E17-15^{88}	Top of unconfined	Q	Q	RCRA	216-A-29
299-E17-14^{88}	Top of unconfined	S	Q	RCRA	--
299-E17-9^{68}	Top of unconfined	S	Q	PRE	--
299-E17-5^{65}	Top of unconfined	S	Q	PRE	--

Notes: Superscript following well number denotes the year of installation.
PRE = well was constructed before RCRA-specified standards.
Q = frequency on a quarterly basis.
RCRA = well is constructed to RCRA-specified standards.
S = frequency on a semiannual basis.

Table 2-8. 216-A-36B Crib Groundwater Analytes

Contamination indicator parameters		
pH	Total organic carbon	
Specific conductance	Total organic halogen	
Groundwater quality parameters		
Chloride	Manganese	Sodium
Iron	Phenols	Sulfate
Drinking water parameters		
2,4-D	Endrin	Methoxychlor
2,4,5-TP Silvex	Fluoride	Nitrate
Arsenic	Gross alpha	Radium
Barium	Gross beta	Selenium
Cadmium	Lead	Silver
Chromium	Lindane	Toxaphene
Coliform bacteria	Mercury	Turbidity
Site-specific parameters		
Ammonium ion	Gamma scan	Zinc
Benzyl alcohol	Tritium	

Table 2-9. 216-A-29 Ditch Monitoring Well Summary

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
299-E25-26^{85}	Upper unconfined	Q	M	RCRA	--
299-E25-28^{86}	Deep unconfined	SQ	M	RCRA	--
299-E25-34^{88}	Top of unconfined	SQ	M	RCRA	--
299-E25-35^{88}	Top of unconfined	QQ	M	RCRA	--
299-E25-42^{91}	Top of unconfined	SQ	M	RCRA	--
299-E25-43^{91}	Top of unconfined	SQ	M	RCRA	--
299-E25-47^{92}	Top of unconfined	SQ	M	RCRA	--
299-E25-48^{92}	Top of unconfined	Q	M	RCRA	--
299-E26-12^{91}	Top of unconfined	Q	M	RCRA	--
299-E26-13^{91}	Top of unconfined	Q	M	RCRA	--
299-E25-32P^{88}	Top of unconfined	Q	M	RCRA	--
699-43-43^{88}	Top of unconfined	Q	M	RCRA	B Pond
699-43-45^{89}	Top of unconfined	Q	M	RCRA	B Pond
299-E17-15^{88} A	Top of unconfined	Q	Q	RCRA	A-36B
299-E17-20^{88} A	Top of unconfined	Q	Q	RCRA	A-10
299-E25-06^{56} A	Top of unconfined	--	Q	PRE	--
299-E25-09^{56} A	Top of unconfined	--	Q	PRE	--
299-E25-10^{58} A	Deep unconfined	--	Q	PRE	--
299-E25-11^{60} A	Deep unconfined	Q	Q	PRE	--
299-E25-18^{76} A	Top of unconfined	Q	Q	PRE	--
299-E25-19^{76} A	Top of unconfined	Q	Q	PRE	--
299-E25-20^{76} A	Top of unconfined	Q	Q	PRE	--
299-E25-21^{83} A	Top of unconfined	Q	Q	PRE	--
299-E25-31^{87} A	Top of unconfined	Q	Q	RCRA	--
299-E25-36^{88} A	Top of unconfined	Q	Q	RCRA	A-10
299-E26-02^{58} A	Top of unconfined	--	Q	PRE	--

Notes: Superscript following well number denotes the year of installation.
A = assessment program well that is sampled for supplementary data.
M = frequency on a monthly basis.
PRE = well was constructed before RCRA-specified standards.
Q = frequency on a quarterly basis.
RCRA = well is constructed to RCRA-specified standards.

Table 2-10. 216-A-29 Ditch Groundwater Analytes

Contamination indicator parameters		
pH Specific conductance	Total organic carbon Total organic halogen	
Groundwater quality parameters		
Chloride Iron	Manganese Phenols	Sodium Sulfate
Drinking water parameters		
2,4-D 2,4,5-TP Silvex Arsenic Barium Cadmium Chromium Coliform bacteria	Endrin Fluoride Gross alpha Gross beta Lead Lindane Mercury	Methoxychlor Nitrate Radium Selenium Silver Toxaphene Turbidity
Site-specific parameters for the 216-A-29 Ditch		
Ammonium	Hydrazine	Tritium
Assessment monitoring parameters for the 216-A-29 Ditch		
Anions Herbicides ICP metals	Pesticides Polychlorinated biphenyls	Semi-volatile organic compounds Volatile organic compounds

ICP = inductively coupled plasma, spectrogram method of analysis.

Table 2-11. 2101-M Pond Monitoring Well Summary

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
299-E18-1[88]	Top of unconfined	Q	M	RCRA	B Pond
299-E18-2[88]	Top of unconfined	S	M	RCRA	--
299-E18-3[88]	Top of unconfined	S	M	RCRA	--
299-E18-4[88]	Top of unconfined	S	M	RCRA	--

Notes: Superscript following well number denotes the year of installation.
M = monthly sampling frequency.
Q = quarterly sampling frequency. Well 299-E18-1 is sampled on a quarterly basis because it is also designated as an upgradient well for the 216-B-3 Pond system.
RCRA = well is constructed to RCRA-specified standards.
S = semiannual sampling frequency.

Table 2-12. **2101-M Pond Groundwater Analytes**

Contamination indicator parameters		
pH Specific conductance	Total organic carbon Total organic halogen	
Groundwater quality parameters		
Chloride Iron	Manganese Phenols[a]	Sodium Sulfate
Drinking water parameters		
Arsenic Barium Cadmium Chromium	Coliform[a] Fluoride Gross alpha Gross beta	Nitrate Selenium Silver
Site-specific parameters		
Turbidity	Uranium[b]	

[a]Analyzed once a year.
[b]Will be analyzed for only a few times to help establish background contamination and groundwater flow direction.

Table 2-13. 216-B-3 Pond System Monitoring Well Summary

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
299-E18-1[88]	Top of unconfined	Q	M	RCRA	2101-M
299-E32-4[87]	Top of unconfined	Q	M	RCRA	LLWMA-2
699-40-36[92]	Top of unconfined	Q	M	RCRA	W-049H
699-40-39[89]	Top of unconfined	Q	M	RCRA	--
699-40-40A[91]	Lower unconfined	Q	M	RCRA	--
699-40-40B[91]	Top of unconfined	Q	M	RCRA	--
699-41-35[92]	Top of unconfined	Q	M	RCRA	W-049H
699-41-40[89]	Top of unconfined	Q	M	RCRA	--
699-41-42[92]	Top of unconfined	Q	M	RCRA	--
699-42-37[92]	Top of unconfined	Q	M	RCRA	W-049H
699-42-39A[91]	Top of unconfined	Q	M	RCRA	--
699-42-39B[91]	Lower unconfined	Q	M	RCRA	---
699-42-40A[81]	Top of unconfined	Q	M	PRE	---
699-42-41[91]	Top of unconfined	Q	M	RCRA	---
699-42-42B[88]	Top of unconfined	Q	M	RCRA	---
699-43-40[91]	Top of unconfined	Q	M	RCRA	--
699-43-41E[89]	Top of unconfined	Q	M	RCRA	--
699-43-41F[89]	Lower unconfined	Q	M	RCRA	--
699-43-41G[91]	Top of unconfined	Q	M	RCRA	--
699-43-42J[88]	Lower unconfined	Q	M	RCRA	--
699-43-43[88]	Top of unconfined	Q	M	RCRA	A-29
699-43-45[89]	Top of unconfined	Q	M	RCRA	A-29
699-44-39B[92]	Top of unconfined	Q	M	RCRA	--
699-44-42[88]	Top of unconfined	Q	M	RCRA	--
699-44-43B[89]	Top of unconfined	Q	M	RCRA	--

Notes: Superscript following well number denotes the year of installation.
M = frequency on a monthly basis.
PRE = well was constructed before RCRA-specified standards.
Q = frequency on a quarterly basis.
RCRA = well is constructed to RCRA-specified standards.

Table 2-14. 216-B-3 Pond System Groundwater Analytes

Contamination indicator parameters		
pH Specific conductance	Total organic carbon Total organic halogens	
Groundwater quality parameters		
Chloride Iron	Manganese Phenols	Sodium Sulfate
Drinking water parameters		
2,4-D 2,4,5-TP Arsenic Barium Cadmium Chromium Coliform bacteria Endrin	Fluoride Gross alpha Gross beta Lead Lindane Mercury Methoxychlor	Nitrate Radium Selenium Silver Toxaphene Turbidity
Site-specific parameters		
Ammonium	Hydrazine	Tritium
Assessment monitoring parameters		
Anions Herbicides Pesticides	Polychlorinated biphenyls Volatile , semi-volatile organic compounds	

Table 2-15. Nonradioactive Dangerous Waste Landfill Monitoring Well Summary

Well	Aquifer	Sampling frequency	Water levels	Well standards	Other networks
699-26-33[86]	Top of unconfined	SA	M	RCRA	--
699-26-34A[86b]	Top of unconfined	SA	M	RCRA	--
699-26-34B[92]	Top of unconfined	Q	M	RCRA	--
699-26-35A[86]	Top of unconfined	SA	M	RCRA	SWL
699-25-35C[87]	Top of LPU[a]	SA	M	RCRA	--
699-25-33A[87]	Top of LPU[a]	SA	M	RCRA	--
699-25-34A[86]	Top of unconfined	SA	M	RCRA	--
699-25-34B[86]	Top of unconfined	SA	M	RCRA	--
699-25-34D[92]	Top of unconfined	Q	M	RCRA	--

Notes: Superscript number following well number denotes the year of installation.
[a]Low permeability unit in the upper Ringold Formation.
[b]Well previously named 699-26-34.
LPU = low permeability unit.
M = sampled or measured on a monthly basis.
Q = sampled or measured on a quarterly basis.
RCRA = well is constructed to RCRA-specified standards.
SA = sampled or measured on a semiannual basis.
SWL = Solid Waste Landfill.

Table 2-16. Nonradioactive Dangerous Waste Landfill Groundwater Analytes

Contamination indicator parameters		
pH Specific conductance	Total organic carbon Total organic halogen	
Groundwater quality parameters		
Chloride Iron	Manganese Phenols	Sodium Sulfate
Drinking water parameters		
2,4-D 2,4,5-TP Silvex Arsenic Barium Cadmium Chromium Coliform bacteria	Endrin Fluoride Gross alpha Gross beta Lead Lindane Mercury	Methoxychlor Nitrate Radium Selenium Silver Toxaphene Turbidity
Site-specific parameters		
Tritium	Volatile chlorinated hydrocarbons	

3.0 HYDROLOGY AND GEOLOGY

The following sections present the hydrology and geology of the 200-PO-1 Operable Unit to assist in the understanding of contaminant fate and transport. The discussions are summarized from the 200 East Groundwater AAMSR (DOE-RL 1992a) and focus on those attributes relevant to the 200-PO-1 Groundwater Operable Unit.

3.1 SURFACE-WATER HYDROLOGY

With the end of nuclear materials production at Hanford and the establishment of the Tri-Party Agreement milestone M-17-10 ("Cease all liquid discharges to hazardous land disposal units unless such units have been clean closed in accordance with the Resource Conservation and Recovery Act"), disposal of process effluents to ditches and ponds has been greatly diminished. As a result, the number of surface water bodies on the Hanford Site has been reduced. In the 200-PO-1 Operable Unit, two ponds currently remain.

The 216-B-3 Pond System is located 1,100 m (3,500 ft) east of the 200 East Area perimeter fence. Until recently, the 216-B-3 Pond System received all waste water produced in the 200 East Area. The 216-B-3 Pond System included the Main Pond and the "lobes" designated as the 216-B-3A Pond, the 216-B-3B Pond, and the 216-B-3C Pond (DOE-RL 1993a). In April 1994, discharges to the main pond were rerouted to the 216-B-3C pond (Figure 3-1). The Main Pond and associated B-3-3 Ditch and B-3A lobe were closed and interim stabilized in 1994. The B-3C Pond is the only active portion of the 216-B-3 Pond System (Smith 1995). During 1994, the volume of effluent discharged to the B-Pond System averaged approximately 11,000 L/min (3,000 gal/min) (DOE-RL 1994b). Effluent in the 216-B-3C Pond infiltrates rapidly into the gravelly soils. If necessary, water can be diverted to the 216-E-25 Contingency Pond located north of the 216-B-3 Pond System.

As mandated by Tri-Party Agreement Milestone M-17-08, the Project W-049H Treated Effluent Disposal Facility (TEDF) (Figure 3-1) was built during 1994 to provide a single permitted soil column disposal site for waste streams from the 200 Areas process facilities meeting best available technology (BAT)/all known, available, and reasonable technologies (AKART) requirements (DOE-RL 1995, DOE-RL 1994b) Operation of the TEDF began in June 1995 at which time several waste streams were rerouted to the TEDF from the B-3C pond. The TEDF consists of 2, five acre disposal basins located 610 m (2000 ft) east of the B-3C Pond. The flow rate to the TEDF is expected to be 2400 l/min (640 gpm) as a monthly average (Denslow et al. 1995).

3.2 GEOLOGY

The geology of the Hanford Site has been extensively characterized as a result of various past investigation activities (Figure 3-2). These activities have included the siting of nuclear reactors (WPPSS 1981 and PSPL 1982), the site characterization efforts of the BWIP (DOE 1988), and support for waste management operations (DOE 1987) and the recent environmental restoration activities. Geologic investigations have included regional and Hanford Site surface mapping, borehole/well sediment logging, field and laboratory sediment classification, surface and borehole geophysical studies (including gamma radiation logging), and in situ and laboratory hydrogeologic properties testing.

The purpose of the following sections is to present a general summary of the geology of the 200-PO-1 Operable Unit; detailed discussions of the Hanford Site and the regional setting can be found in DOE (1987 and 1988), Myers et al. (1979), and Reidel and Hooper (1989) among others. More recently, Delaney et al. (1991) and Reidel et al. (1992) have presented geologic summaries of the Hanford Site.

3.2.1 Geologic Setting

The 200-PO-1 Operable Unit is located in the central part of the Pasco Basin (Figure 3-3), a broad structural and topographic basin formed by structural deformation of thick sequences of tholeiitic flood basalts, intercalated sediments of the Ellensburg Formation, and suprabasalt sediments. The basalts of the Columbia River Basalt Group, were extruded between 17 and 6 million years ago. Unconsolidated and partly consolidated sediments of Miocene through Pleistocene age overly the basalts.

The Pasco Basin is bounded mostly by east-west trending anticlines. The approximate boundaries of the basin are the Saddle Mountains to the north, the broad north-south trending Jackass Mountain Monocline to the east, the Rattlesnake Hills to the south, and the Hog Ranch - Naneum Ridge anticline to the west (Figure 3-3). The basin is underlain by at least 3,200 meters (10,500 ft) of Columbia River Basalt which is in turn overlain by 0 to over 215 meters (0 to over 700 ft) of fluvial, lacustrine, glaciofluvial, and eolian sediments (Myers et al. 1979). Three sedimentary units overly the basalt: the late Miocene to Pliocene Ringold Formation, the pre-Missoula gravels, and the Pleistocene Hanford formation. Surficial deposits of loess, dune sand, alluvial sand, landslide material, talus, and colluvium of recent age are also present (Figure 3-4). The Operable Unit is located within these unconsolidated sediments overlying the Columbia River Basalt Group.

3.2.2 Columbia River Basalt Group

The basalt flows of the Columbia River Basalt Group were extruded during Miocene time from vents in southeastern Washington, Northern Oregon, and eastern Idaho. Epiclastic and volcaniclastic sediments of Miocene age are interbedded in the basalt and are designated the Ellensburg Formation (Swanson et al. 1979).

Beneath the 200-PO-1 Operable Unit, the youngest and uppermost basalts present are member of the Saddle Mountains Basalt Formation of the Columbia River Basalt Group (Myers et al. 1979). The Saddle Mountains Basalt is divided into the Ice Harbor, Elephant Mountain, Pomona, Esquatzel, Asotin, Wilbur Creek, and Umatilla Members (Figure 3-5). The Elephant Mountain

Member is the uppermost basalt unit beneath most of the Hanford Site except in the vicinity of the 300 Area where the overlying Ice Harbor Member is encountered and north of the 200 Areas where the Saddle Mountains Basalt has been locally eroded down to the Umatilla Member.

The Elephant Mountain Member is the uppermost basalt unit throughout the western and central 200-PO-1 Operable Unit where it generally overlies the Rattlesnake Ridge interbed but is locally invasive into the underlying sediments (Myers et al. 1979). The Elephant Mountain member consists of two separate flows, the Elephant Mountain Flow and the Ward Gap flow (Reidel and Fecht 1981). The Elephant Mountain flow is up to 35 m (115 ft) thick, while the Ward Gap flow is up to 20 m (65 ft. thick). A thin silt interbed locally separates the two Elephant Mountain flows (Reidel and Fecht 1981). The Elephant Mountain Member is the uppermost confining layer beneath the 200-PO-1 Operable Unit.

The basalts of the Ice Harbor Member may extend into the southeastern and eastern portion of the 200-PO-1 Operable Unit and overlie the Elephant Mountain basalts. There is inconclusive evidence in borehole cuttings of its presence.

3.2.3 Ellensburg Formation

The Rattlesnake Ridge interbed of the Ellensburg Formation is present between the Elephant Mountain member and the underlying Pomona Member (Figure 3-5). In the Central portion of the Pasco Basin, the interbed ranges from 1.5 to 15 m (5 to 50 ft) in thickness and is composed of clayey basalt conglomerates, fluvial floodplain deposits, and ash tuffs and tuffites (Graham et al. 1984). Beneath most if not all of the 200-PO-1 Operable Unit, the Rattlesnake Ridge interbed comprises the uppermost confined aquifer.

The Levey interbed of the Ellensburg Formation would likely be present in the stratigraphic column should the Ice Harbor basalts extend into the 200-PO-1 Operable Unit.

3.2.4 Suprabasalt Sediments

The geology of the suprabasalt sediments in the 200-PO-1 Operable Unit is well defined in the 200 East Area and at the NRDWL due to the large number and close-spacing of wells drilled at those locations. A lesser degree of confidence exists in the region east of the 200 Area and NRDWL, and north of the 300 Area due to the wide spacing and shallow depths of most boreholes. The suprabasalt sediments beneath the 200-PO-1 Operable Unit are dominated by laterally extensive deposits assigned to the late Miocene to Pliocene-aged Ringold Formation and the Pleistocene-aged Hanford formation (Figures 3-4). The suprabasalt sedimentary sequence ranges up to 700 ft (215 m) thick and contains the uppermost unconfined aquifer. Interpretations of stratigraphy beneath the 200-PO-1 Operable Unit are based on Lindsey et al. (1992), Connelly et al. (1992) and Lindsey (1995). Cross sections depicting the stratigraphy of the 200-PO-1 Operable Unit are presented in Appendix B.

3.2.4.1 Ringold Formation. Sediment samples from the 200 East Area and NRDWL together with projections from the 300 Area indicate that, beneath the 200-PO-1 Operable Unit, the Ringold Formation is composed of fluvial gravel units A, B/D, C, and E; the lower mud sequence; overbank deposits; and the upper Ringold unit (Lindsey 1995) (Appendix B). Ringold unit A, overbank deposits, and the upper Ringold members have not been identified beneath the 300 Area.

Ringold fluvial gravel unit A directly overlies the Elephant Mountain basalt (Figure 3-4). Unit A displays a relatively flat surface that dips towards the axis of the Cold Creek syncline. Unit A generally pinches out in the north portion of the 200-PO-1 Operable Unit against structural highs in the underlying basalt bedrock and is truncated along the eastern margin of the operable unit. Intercalated lenticular sand and silt are found locally in the middle section of the unit A gravels in the southeastern portion of the 200-PO-1 Operable Unit. Unit A ranges in thickness from 15 m (50 ft) in the southwest corner of the 200 East Area to greater than 35 m (115 ft) near the center of the operable unit. Unit A thins to the southeast and has not been identified under the 300 Area.

The fine-grained lacustrine deposits of the lower mud sequence thicken and dip to the southeast in a manner similar to the Ringold fluvial gravel unit A. Like the unit A, the lower mud sequence is absent throughout much of the northern portion of the 200-PO-1 Operable Unit. The lower mud sequence pinches out against structural highs in the basalt bedrock or, in some locations, is truncated by the overlying Ringold fluvial gravel unit E or Hanford formation. Further east the lower mud sequence is overlain by Ringold fluvial gravel unit B/D. Throughout the western portion of the 200-PO-1 Operable Unit the lower mud sequence is overlain by the Ringold fluvial gravel unit E or Hanford formation gravels. The lower mud sequence ranges in thickness from 0 m (0 ft) to more than 33 m (110 ft) in the vicinity of NRDWL, thinning to 6 m (18 ft) near the 300 Area and to 15m (50 ft) toward the northeast near the Columbia River.

Ringold fluvial gravel unit B/D overlies the lower mud unit in the central and eastern portions of the 200-PO-1 Operable Unit (Figure 3-4). It ranges in thickness from 0 m (0 ft) in the west to 15 m (50 ft), thickening to the southeast.

Fluvial gravel unit C is present in the central area of the 200-PO-1 Operable Unit and extends to the southeast corner of the operable unit. The unit pinches out rapidly to the north and west and thickens to the south-southwest up to 38 m (125 ft) into the Cold Creek syncline.

Overbank deposits exist between Ringold fluvial gravel units B/D and C, and units C and E. These deposits consist of laterally discontinuous sand and silt horizons that range in thickness from 0 m (0 ft) to 30 m (100 ft) where gravel units B/D and C exist. The overbank deposits between fluvial gravel units B/D and C are generally thicker than the overbank deposits between gravel units C and E.

Ringold fluvial gravel unit E (Figure 3-4) is present under most of the southern half of the 200 East Area but does not exist eastward to the north-central portion of the 200-PO-1 Operable Unit in the vicinity of the 216-B-3 Ponds. The unit thickens to the east and southeast to as much as

70 m (230 ft). In addition to the gravels typical of unit E, discontinuous silt and sand lenses are present locally.

The upper Ringold unit (Ringold Formation member of Taylor Flat) overlies unit E and is a fine-grained horizon present from in the northeast portion of the operable unit. The unit ranges in thickness from 0 m (0 ft) to 18 m (60 ft), thickening to the east.

3.2.4.2 Pre-Missoula Gravels. The pre-Missoula gravels consist of clast supported, sandy pebble/cobble gravel with a distinctive white or bleached color. This horizon sharply truncates the underlying Ringold Formation, but the nature of the contact between the pre-Missoula gravels and the overlying Hanford formation is not clear. The horizon is absent from the northwest and southeast regions of the 200-PO-1 Operable Unit. It occurs in the central and northeast part of the operable unit, ranging in thickness from 0 m (0 ft) to 46 m (150 ft) and thickens to the southeast. The pre-Missoula gravels have not been identified southward towards the 300 Area.

3.2.4.3 Hanford Formation. The glaciofluvial sands and gravels of the Hanford formation overlie the fluvial and lacustrine sediments of the Ringold Formation in most of the 200-PO-1 Operable Unit, but directly overlie basalt bedrock in the northern portion of the 200 East Area where the Ringold Formation is absent. The Hanford formation in the 200-PO-1 Operable Unit and surrounding localities has been subdivided into three stratigraphic sequences based on texture and grain-size characteristics. These sequences include: (1) the lower gravel sequence H3, (2) the sandy sequence H2, and (3) the upper gravel sequence H1. The lower and upper gravel sequences are composed primarily of gravels typical of the gravel-dominated facies of the Hanford formation. Discontinuous sand and silt beds more typical of the sand- and silt-dominated facies also are sporadically present in these sequences. The sandy sequence, which in most locations stratigraphically separates the lower and upper gravel sequences, contains upward fining packets of coarse to fine sand typical of the sand-dominated facies of the Hanford formation. Sporadic and discontinuous lenses of gravel and silt are also present, which are more representative of the gravel- and silt-dominated facies of the formation. A transitional horizon, H2A, sometimes separates the lower gravel from the sandy sequence and is composed primarily of fine-grained deposits, but with significantly more gravel present than the sandy sequence typically contains.

The lower gravel sequence is composed of a heterogeneous mix of gravels, sand, and some silt. The sequence ranges in thickness to 44 m (144 ft), and is found throughout most of the 200-PO-1 Operable Unit, thinning to the southwest. In locations where the sandy sequence is absent, the lower gravel sequence is directly overlain by the upper gravel sequence. At these locations the units are indistinguishable.

The transitional sequence is a laterally discontinuous, coarsening upward horizon with characteristics of both the sandy sequence and the gravel sequence. This sequence is limited to the northern portion of the 200-PO-1 Operable Unit and ranges in thickness from 0 m (0 ft) to 26 m (85 ft).

The sandy sequence consists of a heterogenous mixture of sand and silt with minor amounts of gravel. Texturally, the sandy sequence exhibits graded bedding with multiple packets of fining upward sequences. Fine to coarse sands dominate to the north while silt dominates to the south. Thin lenticular silty paleosols with high carbonate content have been found in the northern part of the 200-PO-1 Operable Unit within the sandy sequence. The sandy sequence pinches out to the north of the 200-PO-1 Operable Unit but dips and thickens to the west of the 200-PO-1 Operable Unit. Maximum thickness of the sandy sequence exceeds 79 m (260 ft) in the western portion of the 200-PO-1 Operable Unit and is missing in the northeast. Clastic dikes are randomly distributed in the sandy sequence, typically oriented in a near-vertical position.

The upper gravel sequence of the Hanford formation consists of a heterogeneous mix of gravels, sand, and some silt, similar to the lower gravel sequence. The upper and lower gravel sequences are so similar that without the intervening sandy sequence, the upper gravel sequence cannot be distinguished from the lower gravel sequence. The sequence ranges in thickness up to 23 m (75 ft) near the northern edge of the 200-PO-1 Operable Unit. The upper gravel sequence forms an elongate, northwest to southeast-trending gravel tract through the operable unit. Clastic dikes have been observed that crosscut this sequence.

3.3 HYDROGEOLOGY

This section describes the hydrostratigraphic and groundwater flow characteristics of the basalt aquifers, unconfined aquifer, and vadose zone sediments in the 200-PO-1 Operable Unit.

3.3.1 200 East Area Hydrostratigraphy

The primary hydrostratigraphic units in the 200 East Area are (1) the Rattlesnake Ridge interbed and deeper interbeds of the Ellensburg Formation (confined water-bearing zones); (2) the Elephant Mountain Member and deeper flows of the Saddle Mountains Basalt (confining horizons with local interflow zones); (3) the Ringold Formation (locally semiconfined to confined water-bearing zones in unit A gravels beneath the lower mud sequence, and unconfined aquifer in unit A and unit E gravels); and (4) the Hanford formation (unconfined aquifer and vadose zone sediments) (Figure 3-6). Ringold Unit E and the Hanford Formation are often indistinguishable. The hydrogeologic designations for the 200 East Area were presented in DOE-RL (1992a) and Delaney et al. (1991).

3.3.1.1 Basalt Aquifers. Several regional confined aquifers exist within the Saddle Mountains Basalt-Ellensburg Formation hydrostratigraphic unit in the 200-PO-1 Operable Unit. The confined water-bearing zones occur in the interbeds of the Ellensburg Formation and in interflow and fractured intraflow zones within the basalts. The dense entablature or fracture filled portions of the basalts act as confining layers.

The uppermost regional confined aquifer in the vicinity of the 200-PO-1 Operable Unit is generally within the Rattlesnake Ridge interbed of the Ellensburg Formation but includes the fractured flow top and bottom of the enclosing basalt flows. The upper confining unit, the

Elephant Mountain Member has been locally removed by erosion north of the 200 East Area. and the Rattlesnake Ridge interbed is in contact with the unconfined aquifer in that area. There is no evidence of erosion of the Elephant Mountain in the 200-PO-1 Operable Unit. Transmissivity data for the Rattlesnake Ridge Aquifer is summarized by Newcomer et al. (1992). Reported transmissivities range from 2.1 x 10^{-1} to 173 m^2/day (3 to 1540 ft^2/day).

Jensen (1987), Graham et al. (1984) and Gephart et al. (1979) discuss the presence of an additional confined aquifer associated with the Elephant Mountain Member in the southeastern corner of the 200 East Area. Where both flow units of the Elephant Mountain Member are present, a groundwater interflow zone consisting of sand and clays occurs between the upper and lower flows. The interflow zone is referred to as the Elephant Mountain aquifer (Jensen 1987) but is not regionally extensive. The Elephant Mountain aquifer merges with the unconfined aquifer in the northeast corner of the 200 East Area where the lower Elephant Mountain Flow is absent.

3.3.1.2 Uppermost Aquifer System. The uppermost aquifer system in the 200-PO-1 Operable Unit is primarily unconfined but includes localized semiconfined and confined areas. As discussed by Connelly et al. (1992) and Weekes et al. (1987), the unconfined aquifer in the 200-PO-1 Operable Unit occurs primarily within sediments of the Ringold and Hanford formations. The base of the unconfined aquifer throughout the majority of the operable unit is the Ringold Lower Mud Unit except where the unit is absent in the northern and central portions of the 200 East Area. The thickness of the uppermost aquifer system ranges considerably from near zero in the northeastern portions of the operable unit where basalt bedrock extends above the water table to more than 137 m (450 ft) at the NRDWL. A distinct unconfined system does not exist where the fine-grained sediments of the Ringold lower mud unit form a confining layer above the uppermost aquifer near the 216-B-3 Pond.

In the northern and central part of the 200 East Area, the water table is located within the Ringold unit A gravels while further south and east, the water table intersects the gravely sediments of the Ringold unit E and the Hanford formation (Connelly et al. 1992). Eastward, at the NRDWL, the water table occurs in the Hanford formation, some 15-21 m (50-70 ft) above the Hanford-Ringold contact.

Connelly et al. (1992) report that a distinct unconfined aquifer is absent in the vicinity of the 216-B-3 Pond where the top to the Ringold lower mud coincides with the water table. In the 216-B-3 Pond area, the Ringold lower mud sequence appears to have little moisture and water is generally not encountered during drilling until the underlying gravels are penetrated. The potentiometric surface for the gravels is approximately even with the top of the lower mud sequence because of the local confining conditions. These groundwater elevations represent the potentiometric surface associated with semiconfined to confined groundwater in the Ringold lower mud sequence/unit A gravels. It is also possible that due to groundwater recharge at the B-Pond system, mounded groundwater could extend above the upper surface of the lower mud sequence as perched water.

Hydraulic conductivity data for the unconfined aquifer at 200-PO-1 RCRA sites are presented in Table 3-1 (DOE-RL 1994b). Additional transmissivity data are presented in Newcomer et al.

(1992), Swanson et al. (1992), and Connelly et al. (1992). A map of the transmissivity of the Hanford Site is presented in Figure 3-7.

3.3.1.3 Vadose Zone. In the vicinity of the 200 East Area in the northwest corner of the 200-PO-1 Operable Unit, the vadose zone extends across the three units of the Hanford formation (Connelly et al. 1992). The lowermost vadose zone contains a few feet of the Ringold gravel unit A throughout the western and central portions of the 200 East Area. The lowermost portion of the vadose zone also contains the Ringold lower mud unit to the east beyond 216-B-3 Pond and the TEDF (Davis et al. 1993). The vadose zone is exclusively comprised of the Hanford formation in the vicinity of the NRDWL (Weekes et al. 1987). Eastward toward the Columbia River at the 316-4 Crib, Fecht and Ford (1994) report that the vadose zone is within the Hanford formation.

The vadose zone beneath the 200 East Area ranges from about 97 m (317 ft) thick along the southern part of the eastern PUREX Plant Aggregate Area boundary to 37 m (123 ft) thick in the vicinity of the 216-B-3C Pond, based on December 1994 groundwater elevations (Serkowski et al. 1995). The vadose zone is approximately 40 m (131 ft) thick at the NRDWL and thins eastward toward the river. The observed difference in vadose zone thickness is the result of both surface topography and water-table elevations. The depth to groundwater in the 216-B-3 Pond area is influenced by groundwater mounding and the presence of the Ringold lower mud sequence.

3.3.2 200-PO-1 Groundwater Recharge

Recharge to the unconfined aquifer within the 200 East Area of the 200-PO-1 Operable Unit originates predominantly from artificial sources. Precipitation is the only source of natural recharge. Artificial recharge occurs from several active or recently active cribs, trenches, ditches, ponds, and drains located throughout the 200 East Area, as well as from leaks in pipelines, transfer lines, and spills. The 216-B-3C Pond and the recently activated TEDF are the only recognized sources of artificial recharge outside of the 200 East Area in the 200-PO-1 Operable Unit.

3.3.2.1 Natural Recharge. Within the 200-PO-1 Operable Unit, natural recharge originates from precipitation. Annual precipitation for the Hanford Site is approximately 16 cm (6.3 in.). Evapotranspiration is considered to significantly reduce the amount of precipitation that reaches the groundwater (Gee 1987). Estimates for the percentage of evapotranspiration range from 38% to 99%. The primary factors affecting recharge are surface soil type, vegetation type, topography, and spatial and temporal variations in seasonal precipitation. A modeling analysis (Smoot et al. 1989) indicated that 68% to 86% of the precipitation falling on a gravel-covered site might infiltrate to a depth greater than 2 m (6 ft). However, a study using a gravel-covered lysimeter at the 200 East Area indicated no recharge had occurred in soil 4.9 m (16 ft) below surface over a 16-year period (Rockhold et al. 1990). Gee (1987) conducted recharge analyses for two different soil types, and concluded that recharge rates vary from 0.1 cm/yr (0.04 in./yr) for a fine-textured soil with deep-rooted vegetation, to 10 cm/yr (4 in./yr) for a coarse-grained soil (gravel) devoid of vegetation. Because the 200-PO-1 Operable Unit is covered by sparse vegetation and eolian sand, it is likely that recharge approaches the 0.1 cm/yr (0.04 in./yr) rate. The volume of natural recharge is significantly lower than the volumes of artificial discharges recorded when the 200 East processing plants were operational. Routson and Johnson (1990) conducted a lysimeter study 1.6 km (1 mi) south of the 200 East Area and concluded that no downward moisture movement was observed over a 13 year period.

3.3.2.2 Artificial Recharge. Artificial recharge to the groundwater system began in 1944 and continues through the present. Sources of artificial recharge in the past included cribs, ditches, trenches, ponds, basins, and drains. Recently, liquid discharge to the soil column has been reduced and effluent management facilities activated. The effluent management facilities and sanitary septic systems identified below handle all liquid discharges in the 200 Area.

Septic Systems - Seven septic tank and drain fields are reported to be active within the PUREX Plant Aggregate Area. There are two septic tanks and drain fields in the Semi-Works Aggregate Area and also 18 septic tanks and drain fields/tile fields that are actively discharging water to the soil in the B Plant Aggregate Area which may affect the 200-PO-1 Operable Unit aquifer system. The combined discharge rates are estimated at 97,650 l/day (25,800 gal/day), according to the Waste Information Data System (WIDS) database.

Treated Effluent Disposal Facility (Project W049) - This facility is located east of the 200 East Area (Figure 3-1). The TEDF receives treated effluents from operating facilities located in both the 200 East and West areas. The effluent is sent to the TEDF Disposal Basins located east of the B-Pond Complex. The TEDF is currently receiving effluents at a rate of approximately 1514 L/min (400 gal/min).

216-B-3C Pond - This facility, located east of the 200 East Area (Figure 3-1), currently receives effluents via underground piping from the 284-E Powerhouse, B-Plant cooling water, 242-A evaporator cooling water and steam condensate, 241-A tank farm cooling water, and 242-AR vault cooling water.

3.3.3 200-PO-1 Groundwater Flow

Groundwater flow beneath the 200 East Area portion of the 200-PO-1 Operable Unit is complex and changing. This complexity is due to a regional rise in the water table from past discharges, the convergence of the regional groundwater flow from the 200 West Area with the B Pond (and recently TEDF) artificial recharge, and changes in the total volume of water disposed to the ground. These factors have caused groundwater within the unconfined aquifer to diverge from pre-Hanford flow paths flowing east and southeast toward the Columbia River. In addition, the high transmissivity beneath most of the 200 East Area result in very small hydraulic gradients.

Groundwater levels and chemistry have been actively monitored at the Hanford Site since 1944. This monitoring has been in response to wastewater discharges to the soil which have impacted the natural flow system and chemistry of the groundwater beneath the Hanford Site.

3.3.3.1 Uppermost Aquifer Pre-Hanford Groundwater Flow Conditions. Data are not available on groundwater conditions before the construction and operation of the Hanford Site. However, the pre-Hanford groundwater flow conditions have been proposed by Kipp and Mudd (1974) based on well data accumulated between 1948 and 1951 (Figure 3-8).

Before the initiation of waste disposal activities at the Hanford Site in the mid-1940's, groundwater elevations across the 200 East Area ranged from approximately 119 m (390 ft) above sea level at the western boundary to approximately 117 m (385 ft) at the eastern boundary. The general groundwater flow direction appears to have been from west to east across the Hanford Site with an average hydraulic gradient of 0.001 (Graham et al. 1981). Vertical gradients within the upper unconfined aquifer were probably negligible although a slight upward gradient was present between the basalt aquifers and the unconfined aquifer due to recharge to the basalt aquifers at higher elevations at the edge of the Pasco Basin.

A reduction in hydraulic gradient is observed between the 200 West and 200 East Areas where data provide sufficient resolution. This may be due in part to two hydrostratigraphic factors: (1) the Ringold Formation, which exhibits lower hydraulic conductivities than the Hanford formation, thins to the east, so the flow moves into the more permeable Hanford formation; (2) the basalt dips in a southeasterly direction, which increases the saturated thickness of the unconfined aquifer; and (3) the areal extent of the aquifer increases downgradient of the terminated basalt high (Figures 3-7 and 3-8).

3.3.3.2 Groundwater Flow Conditions during Hanford Operation. Liquid waste disposal activities which are related to the operational status of the 200 East Area Separations Facilities have greatly affected groundwater flow in the 200-PO-1 Operable Unit unconfined aquifer. Within the 200 East Area, discharges to the various waste management units created groundwater mounds in the vicinity of now closed 216-A-25 Pond and the 216-B-3 Pond System. Conditions of the unconfined aquifer have varied with the amount of wastewater discharged from the various waste management units. The following discussion focuses on the historical effects that waste disposal practices have had on the dynamics of the unconfined aquifer (DOE-RL 1992a).

Groundwater Flow from 1944 to 1955. In 1944, groundwater flow in the unconfined aquifer is thought to have occurred essentially from west to east across the operable unit (Figure 3-9). Groundwater levels increased dramatically between 1944 and 1955. Artificial recharge from wastewater discharges created a mound under the 216-B-3 Pond Main Lobe (Figure 3-10). The elevation of groundwater in the vicinity of the pond increased by approximately 6 m (20 ft) during this time. Concurrently, groundwater elevations within the upper Cold Creek valley rose 15 m (50 ft) in response to artificial recharge from agricultural irrigation. By 1955 groundwater mounding under the 216-B-3 Pond had altered the general west to east groundwater flow direction to more of a radial configuration east of the 200 East Area. Gradient increased to the east of the mound, and west of the mound the flow direction temporarily reversed to the west and was then redirected to the north and south.

Groundwater Flow from 1955 to 1965. A comparison of the 1955 and 1965 groundwater contour maps shows that the center of the B-Pond mound remained stationary over this period while groundwater rose 3 m (10 ft) in elevation under the ponds (Figure 3-11). This rise may have been due to increased wastewater discharges from facilities at the newly opened PUREX Plant and reduced operations at the B-Plant. The hydraulic gradient east of the mound increased slightly while flow west of the mound decreased in response to elevated groundwater levels from irrigation in the upper Cold Creek valley and waste disposal in the 200 West Area. Groundwater flow in 1965 from the 200 East Area was directed to the southeast and east, with the exception of a small component of flow from 216-A-25 Pond that was directed to the northwest and Gable Gap.

Groundwater Flow from 1970 to 1987. Groundwater contour maps for 1970 and 1987 (Figures 3-12 and 3-13) show that the B-Pond mound had changed shape due to the permanent closure of the 216-A-25 Pond and the temporary furlough of the PUREX Plant between 1972 and 1983. The mound was rounded instead of elongated, and flow to the west from the mound is divided into components directed to the northwest and to the southeast. Flow from the west into the 200 East Area (i.e., from 200 West Area) underwent a similar division to the northwest and southeast. The increased use of the 216-B-3 Pond after the PUREX restart and the construction of the 216-B-3A, -3B, -3C Pond lobes had elevated the groundwater mound under the 216-B-3 Pond System another 1.5 m (5 ft) by 1987.

Groundwater Flow from 1987 to 1991. The configuration of the regional water table in the 200-PO-1 Operable Unit between 1987 and 1991 changed moderately as a result of the permanent closure of the PUREX Operation and initiatives to reduce the amount of water disposed to the soil (Figure 3-14). The water table beneath the south western 200 East Area dropped up to 1.07 m (3.5 ft) in places while the top of the B-Pond mound lowered approximately 0.6 m (2 ft) (Kasza et al. 1991). The slope on the west side of the mound steepened while the eastern slope remained essentially unchanged. The drop in the water table was recognized in the NRDWL groundwater monitoring network.

Current Groundwater Flow Conditions. Serkowski et al. (1995) compiled water-table measurements for the Hanford Site and contoured the potentiometric surface of the unconfined aquifer for December 1994 (Figure 3-15). In general, groundwater flow paths continue to show an overall trend of flow from west to east across the site, modified by response to artificial recharge, especially to the 216-B-3 Pond System.

The mounding beneath the 216-B-3 Pond System results in radial flow from that area and divides the east directed regional flow into two components: one to the southeast and one to the northwest. The elevated water levels created by the mounding also result in a broad flattening of hydraulic gradients along a northwest-southeast trend that extends through the center of 200 East Area. Because of the mounding, horizontal flowpaths converge on the 200 East Area from the west (regional flow) and from the east (reverse flow). This convergence results in two flowpaths, one to the southeast and one to the northwest through Gable Gap. Flow to the southeast travels to the Columbia River where it discharges to the river from east of Gable Mountain to just north of the 300 Area. Flow to the northwest through Gable Gap reaches the Columbia River at the 100 Area.

The mound beneath 216-B-3 Pond is receding at a rate of about 0.2 m/yr (0.6 ft/yr) (Kasza et al 1992), following the peak discharges of wastewater to the area in the mid-1980's. Wells closer to the center of the mounding show a dissipation rate of approximately 0.3 m/yr (1 ft/yr). The mound high also appears to have shifted to the northwest, perhaps due to elimination of discharges to the Main Pond and B-3A Lobe in 216-B-3 Pond area. Discharge to the 216-B-3 Pond System and other current waste management units is scheduled to be transferred to the Project W-049H TEDF facility just to the east of the C-Lobe. The TEDF likely will maintain mounding of the water table to the west of the 200 East Area.

Eventually, all wastewater discharge in the 200 East Groundwater Aggregate Area is expected to cease and mounding will dissipate completely. Sitewide water levels likely will remain elevated due to recharge from irrigation in upper Cold Creek valley to the west of the Site, but will generally revert to more natural conditions. Groundwater flow in the unconfined aquifer will be toward the east or southeast with a hydraulic gradient in the range of 0.002.

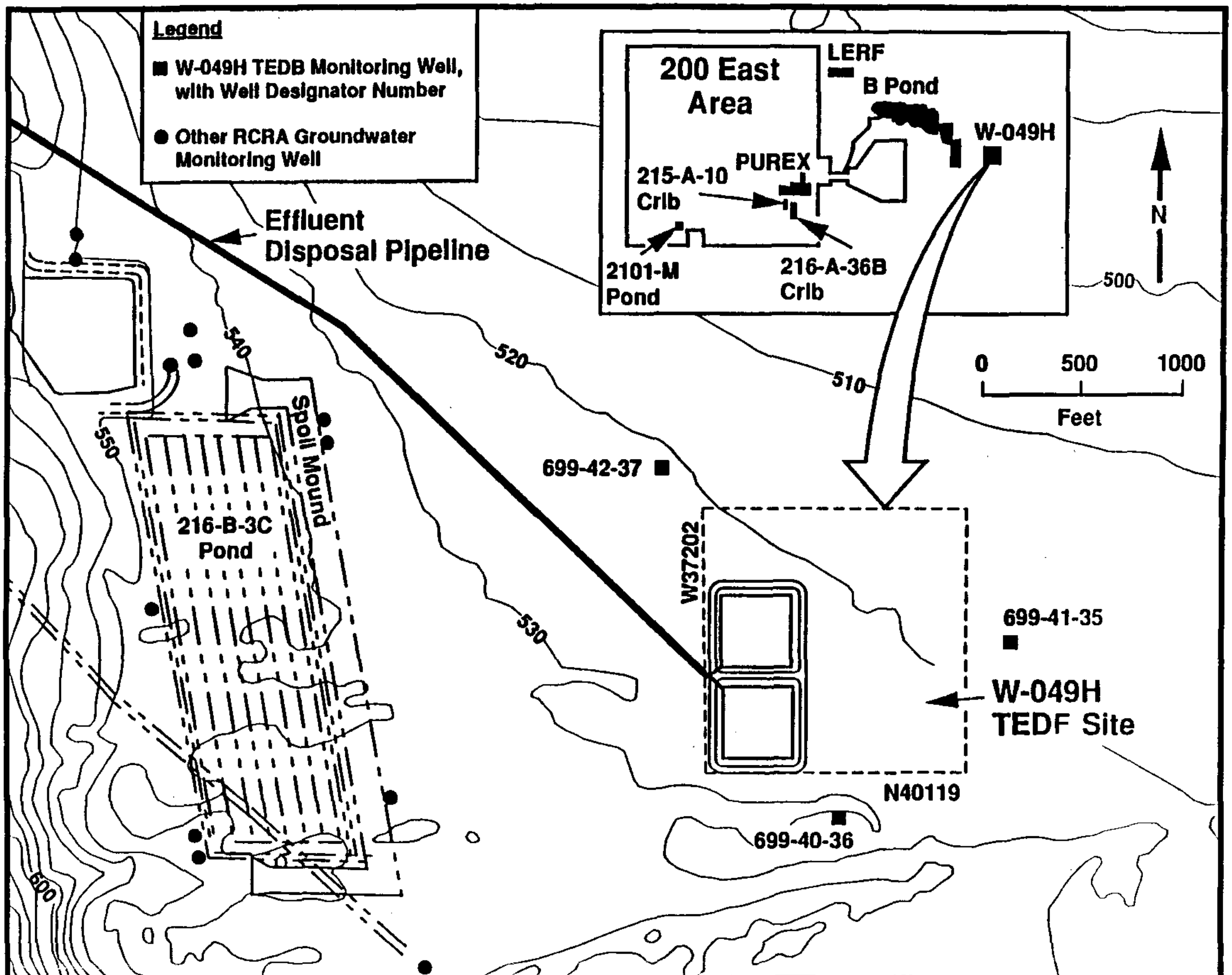
3.3.3.3 Hydraulic Conductivity. Hydraulic conductivity values from existing wells within the 200-PO-1 Operable Unit range from 6×10^{-5} to 9×10^{-2} m/s (17 to 2.5×10^{4} ft/day) (Connelly et al. 1992). A region of high hydraulic conductivity is oriented along a northwest-southeast trend in the northern and eastern parts of the study area (Figure 3-16). The hydraulic conductivity is generally lower (less than 3.5×10^{-3} m/s [1,000 ft/day]) in the southwestern part of the 200 East Area. The high conductivity values are generally associated with the lower gravel unit of the Hanford formation, while the low conductivity values commonly correspond to unit E of the Ringold Formation. Vertical differences in hydraulic conductivity due to lithologic differences can be great, as shown by low values determined by slug and constant discharge tests for the Ringold unit A in the vicinity of the 216-B-3 Pond that are in the order of 3.5×10^{-6} to 3.5×10^{-4} m/s (1 to 100 ft/day). Table 3-1 summarizes hydraulic conductivity data presented for the RCRA sites located in the 200-PO-1 Operable Unit.

3.3.3.4 Vertical Hydraulic Gradient. Groundwater monitoring wells that are screened within the upper portion of the unconfined aquifer exhibit a greater head than the few wells that are screened in the lower portion of the unconfined aquifer. This difference in groundwater elevations indicates a downward vertical gradient. Downward vertical hydraulic gradients within the 200 East Area ranged from indistinguishable (zero) to 0.07 at the groundwater mound beneath the 216-B-3 Pond System (Figure 3-17). Data from nested wells, 299-E25-29P and -29Q, 299-E-25-30P and -30Q, 299-E25-32P and -32Q, and 299-E25-34 and 299-E25-28, located near the Grout Treatment Facility and 216-A-29 Ditch indicate that these paired wells all have indistinguishable vertical head differences (Kasza et al. 1992). Wells 6-43-42J and 6-42-42B located near 216-B-3 Pond and screened in the upper and lower portions of the unconfined aquifer (within the Ringold unit A) have an approximate head difference of 0.6 m (2 ft) over a vertical distance of 9 m (30 ft), and thus the approximate value of the vertical gradient is calculated to be 0.07 (Connelly et al. 1992). These wells may represent conditions that are uncommon to most of the site as the presence of the Ringold lower mud sequence appears to restrict vertical movement, and significant mounding of the water table is present at this location. The lower mud sequence of the Ringold Formation occurs only in the southernmost areas of the 200 East Area. This unit has a low hydraulic conductivity (1.9×10^{-10} m/s [5.3×10^{-5} ft/day]), and where this unit is present it acts as an aquitard separating the basal Ringold gravel (unit A) from the upper unconfined aquifer. Its limited occurrence within the 200 East Area apparently does not significantly affect the vertical hydraulic gradient at the lower unconfined aquifer. As the amount of discharge from the 216-B-3 Pond and other waste management units decreases, the vertical gradients are expected to decrease.

3.3.3.5 Unconfined/Confined Aquifer Intercommunication. As noted in Section 3.3.1.1, the uppermost occurrence of groundwater in the confining basalt sequence beneath the 200-PO-1 Operable Unit is within the Rattlesnake Ridge Interbed of the Ellensburg Formation. Connelly et al. (1992) evaluated the vertical gradient between the unconfined aquifer and Rattlesnake Ridge aquifer through comparison of hydrographs for well clusters. Connelly et al. (1992) found that head trends seen in the uppermost unconfined aquifer are typically mirrored in the Rattlesnake Ridge confined aquifer. This mirroring in the Rattlesnake Ridge aquifer is probably related to the hydraulic interconnectivity of these two aquifers. Generally, the communication between the unconfined aquifer and the Rattlesnake Ridge aquifer is insignificant in most of the 200 East Area, except in two zones where vertical gradients are notable. An extensive area with observed upward hydraulic gradient is present north of the 200 East Area outside the boundaries of the 200-PO-1 Operable Unit (Graham et al. 1984). A downward hydraulic gradient exists in areas surrounding the 216-B-3 Pond System, at the eastern part of the 200 East Area (Kasza et al. 1991).

North of the 200-PO-1 Operable Unit, upward vertical hydraulic gradient conditions exist and the Rattlesnake Ridge interbed discharges directly into the overlying unconfined aquifer where erosion has removed the intervening Elephant Mountain Basalt. The major areas of discharge are around Gable Gap and West Lake, and the erosional window northwest of the 200 East Area (Graham et al. 1984).

Currently, a downward hydraulic gradient occurs around the 216-B-3 Pond area. It also apparently occurred near the Gable Mountain Pond in the late 1960's and early 1970's, when the pond was active and the unconfined groundwater level was higher. The possible existence of an erosional window around the vicinity of the Gable Mountain Pond was hypothesized by Graham et al. (1984), but no hard evidence supports this condition. Connelly et al. (1992) suggest as an alternative that a well-developed fracture system in the Elephant Mountain Basalt could similarly provide intercommunication. Such intercommunication, if present, could provide for potential recharge to the Rattlesnake Ridge interbed from the unconfined aquifer, and the potential for contamination of the confined aquifer.



H9405018.1

Figure 3-1. Location of the 216-B-3C Pond and W-049H TEDF

Figure 3-2. Generalized Geologic Map of the Hanford Site

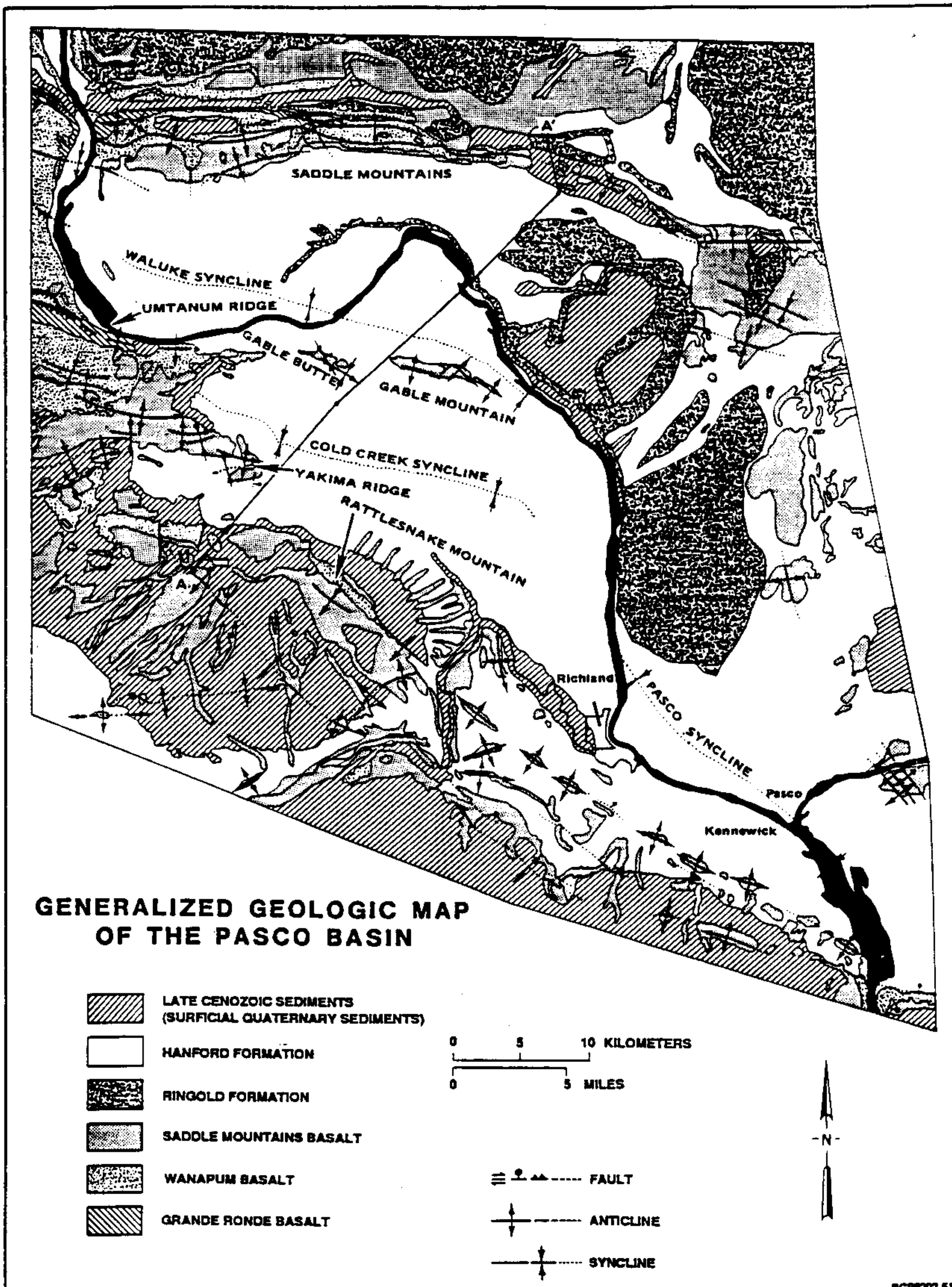
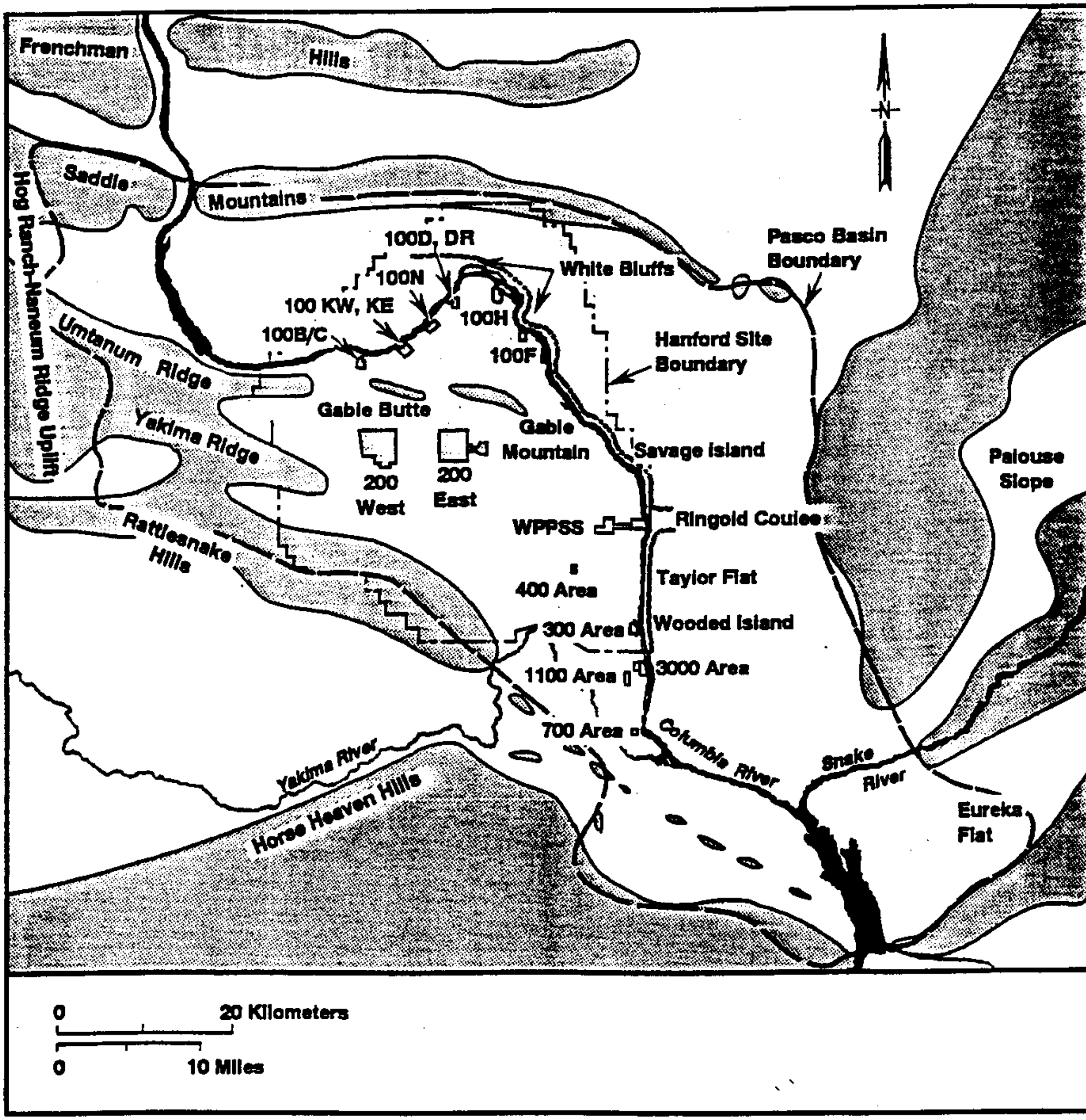


Figure 3-3. Geographic Setting of the Pasco Basin and Hanford Site



H9601006.14

Figure 3-4. Suprabasalt Stratigraphy of the 200 East Area and Vicinity

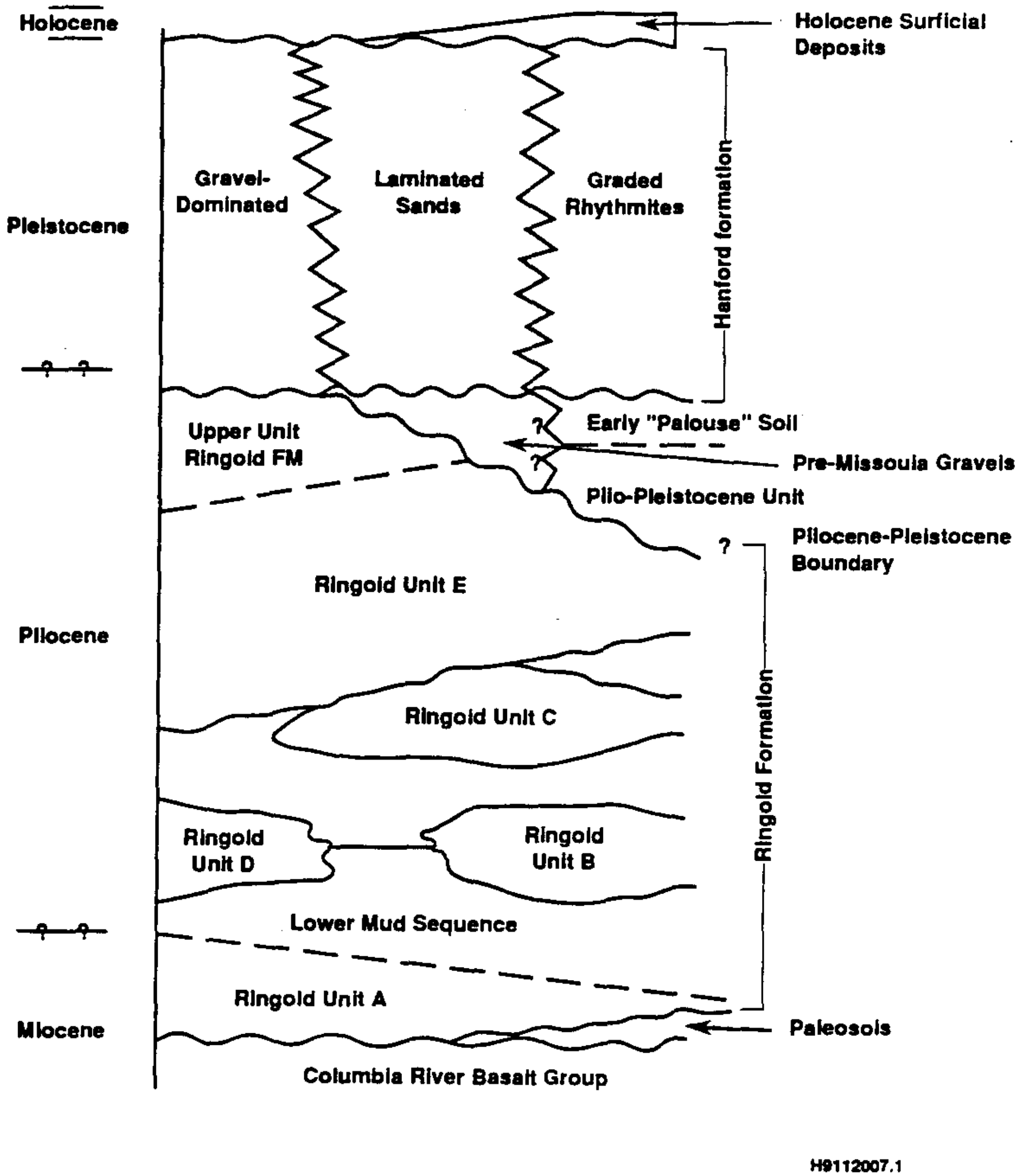
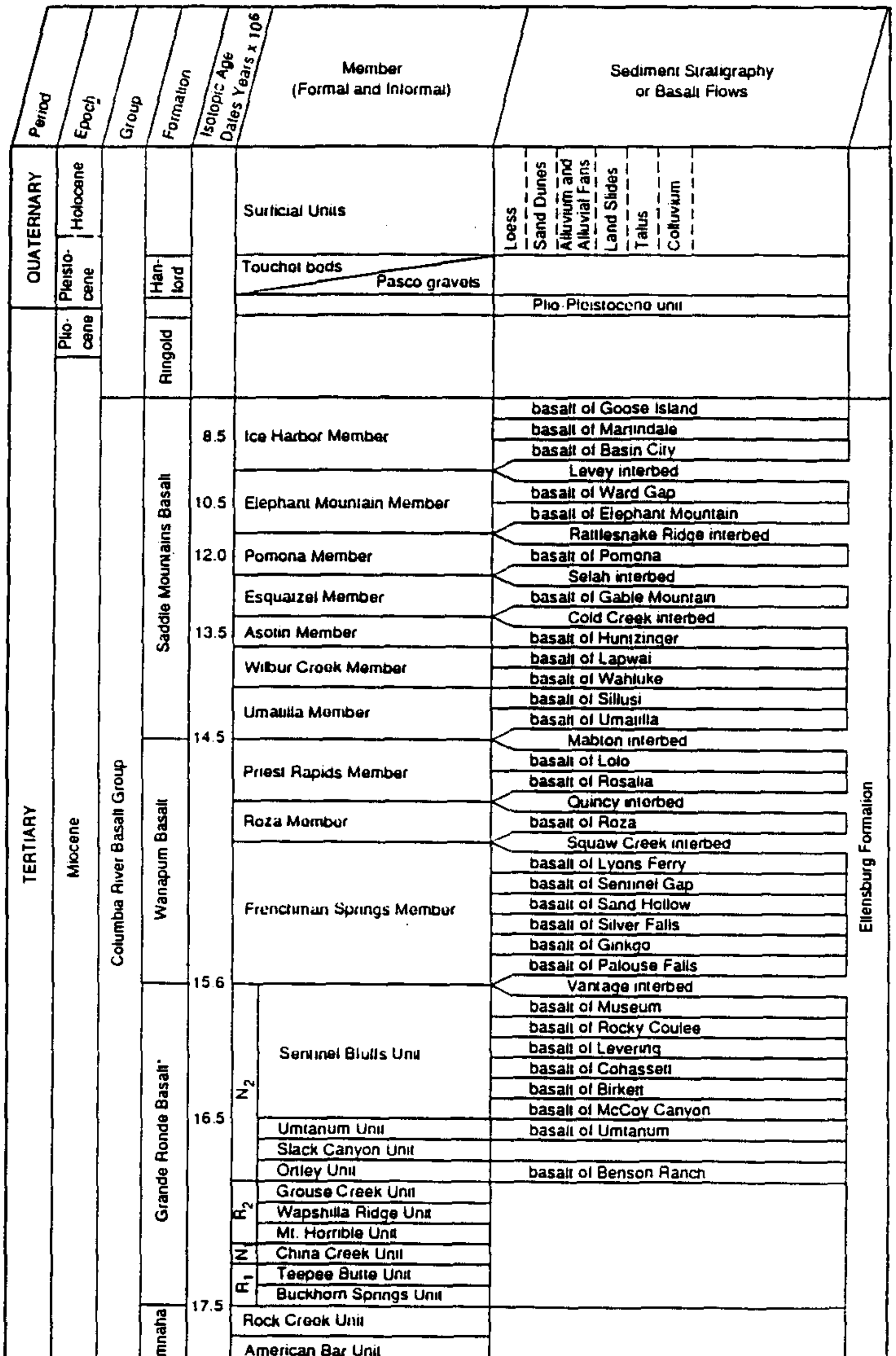


Figure 3-5. Generalized Stratigraphy of the Hanford Site



*The Grande Ronde Basalt consists of at least 120 major basalt flows. Only a few flows have been named.
N_2, R_2, N_1 and R_1 are magnetostratigraphic units.

H9102029.6

Figure 3-6. Conceptual Hydrogeologic Column for the Hanford Site

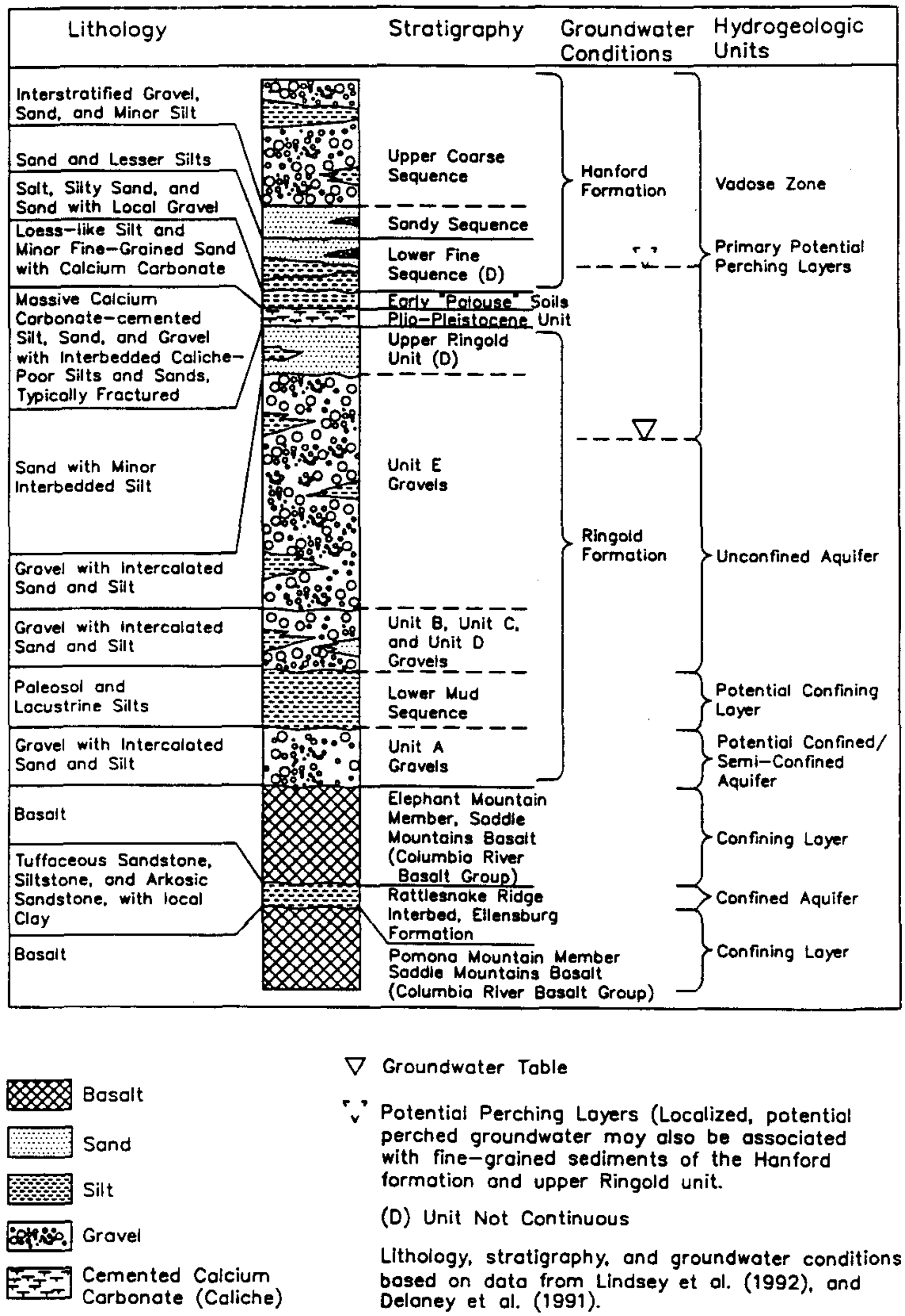
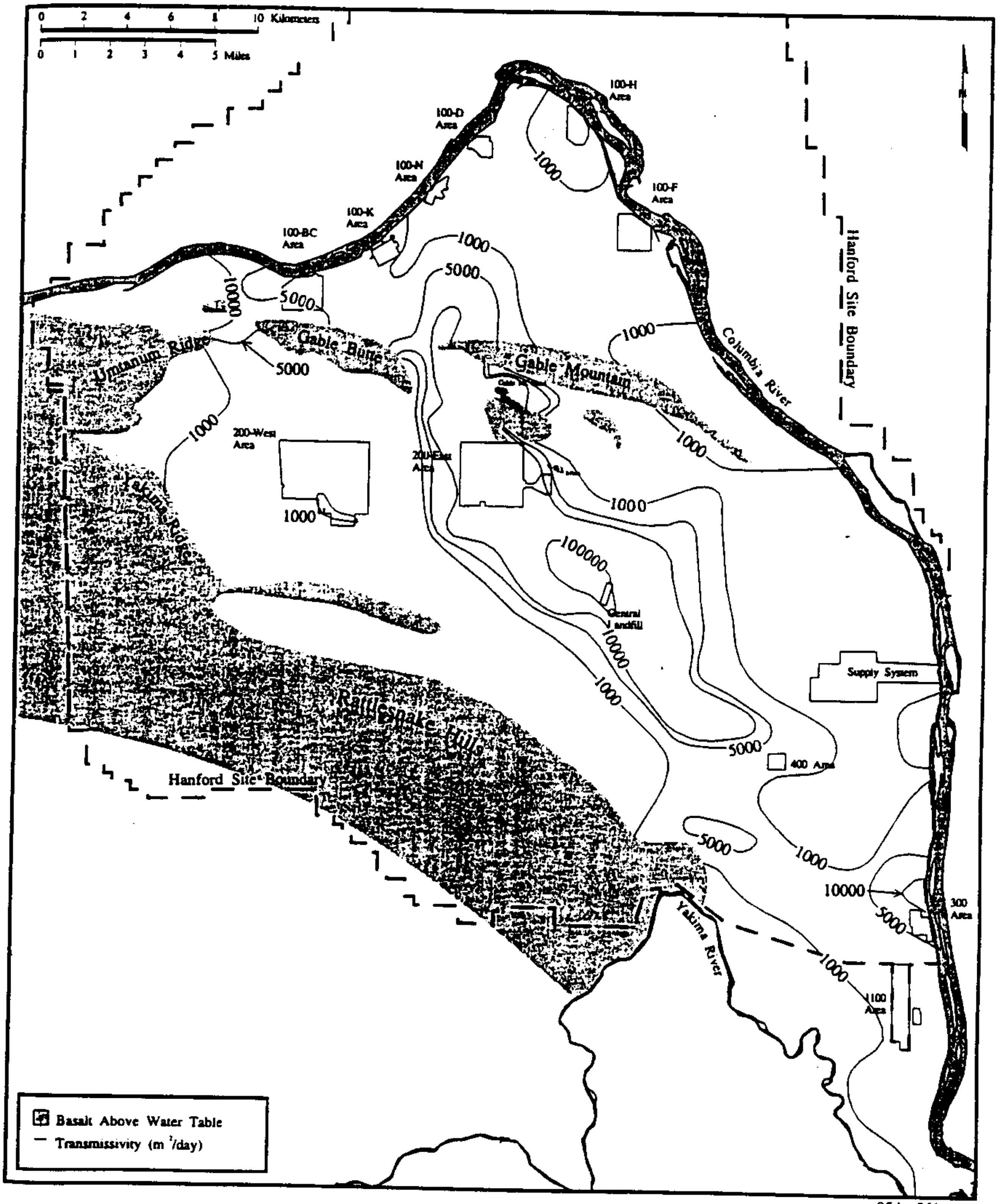


Figure 3-7. Transmissivity in the Unconfined Aquifer at the Hanford Site



95tbw061.eps

Figure 3-8. Hindcast Water Table Map of the Hanford Site, January 1944

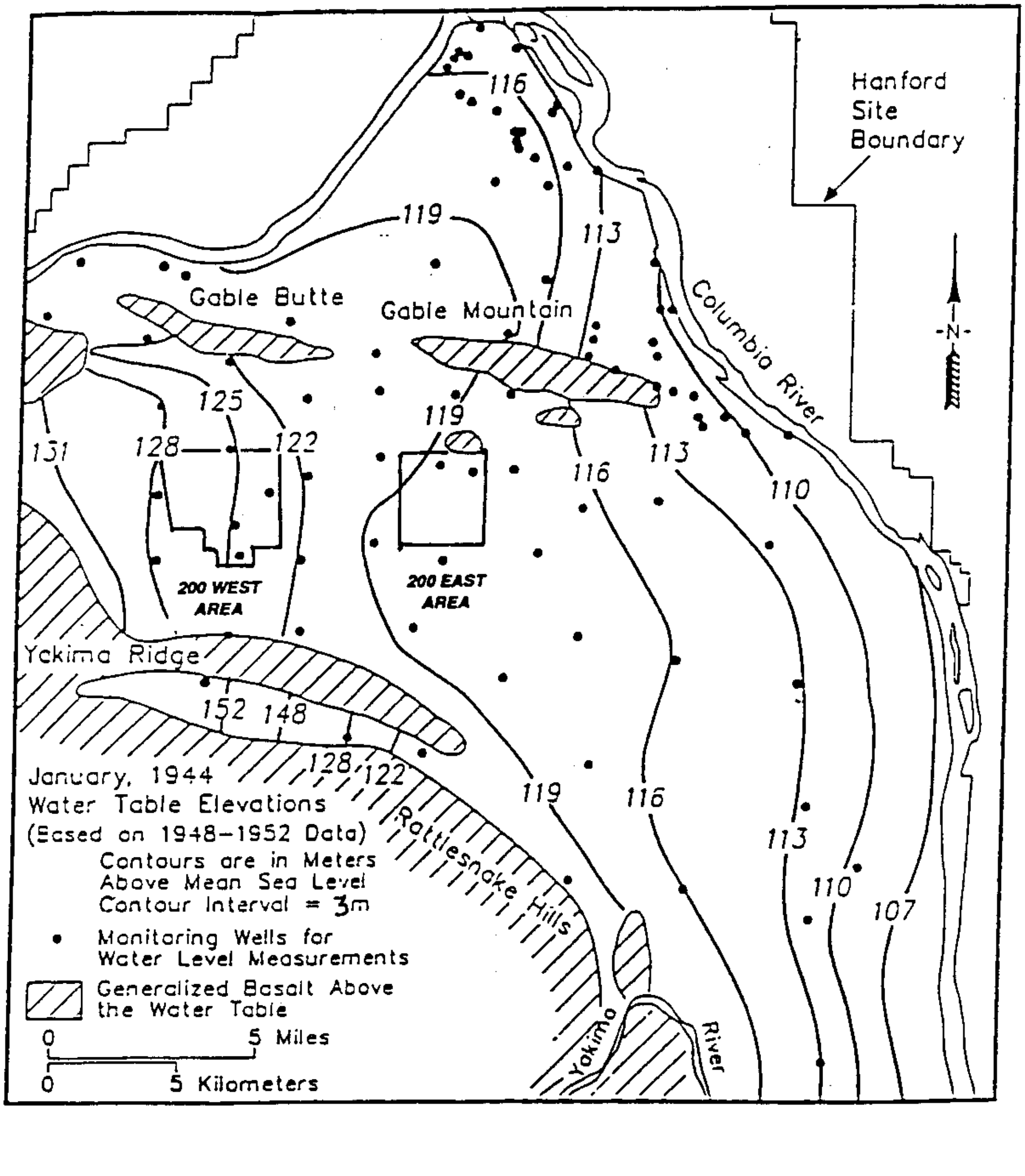
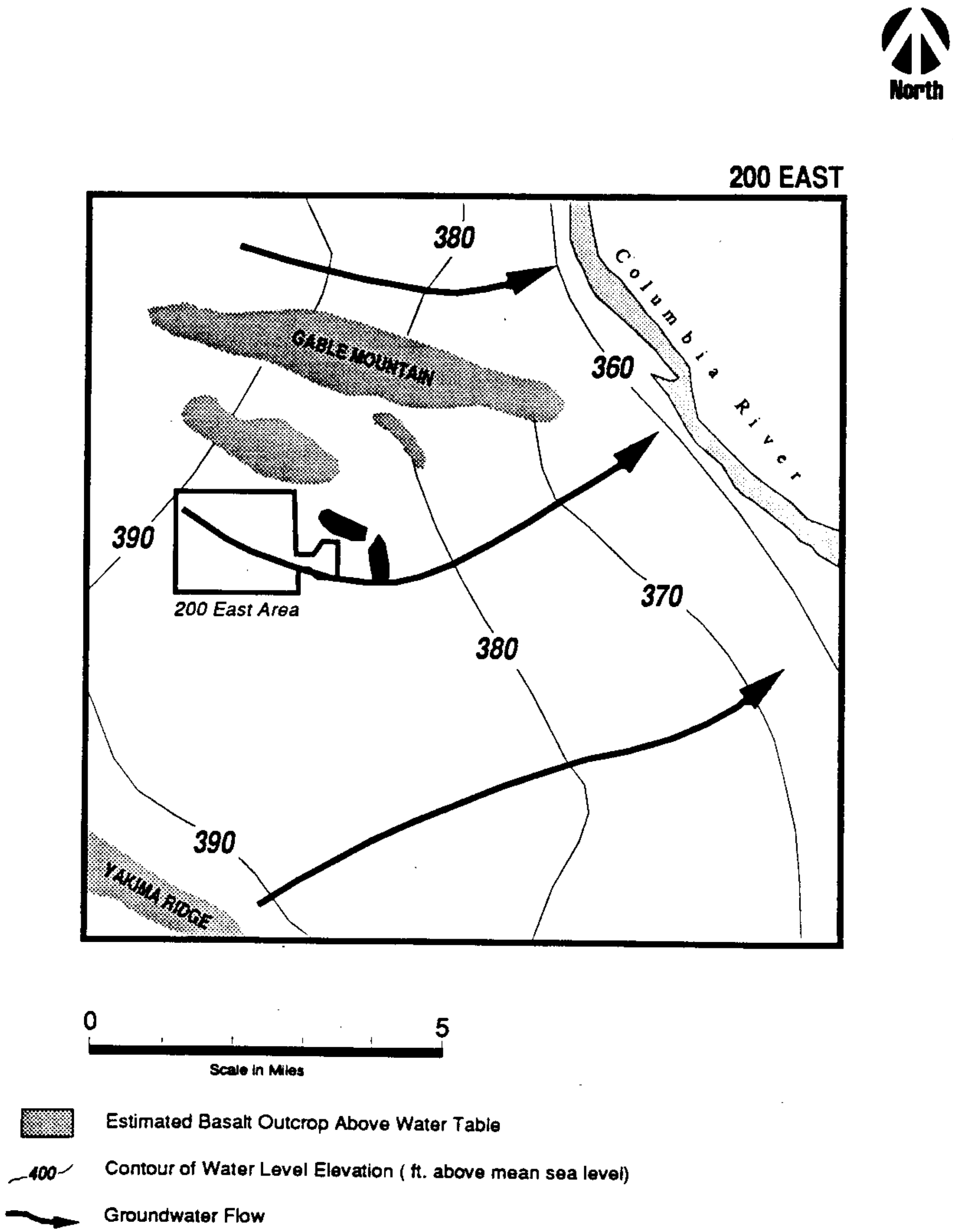
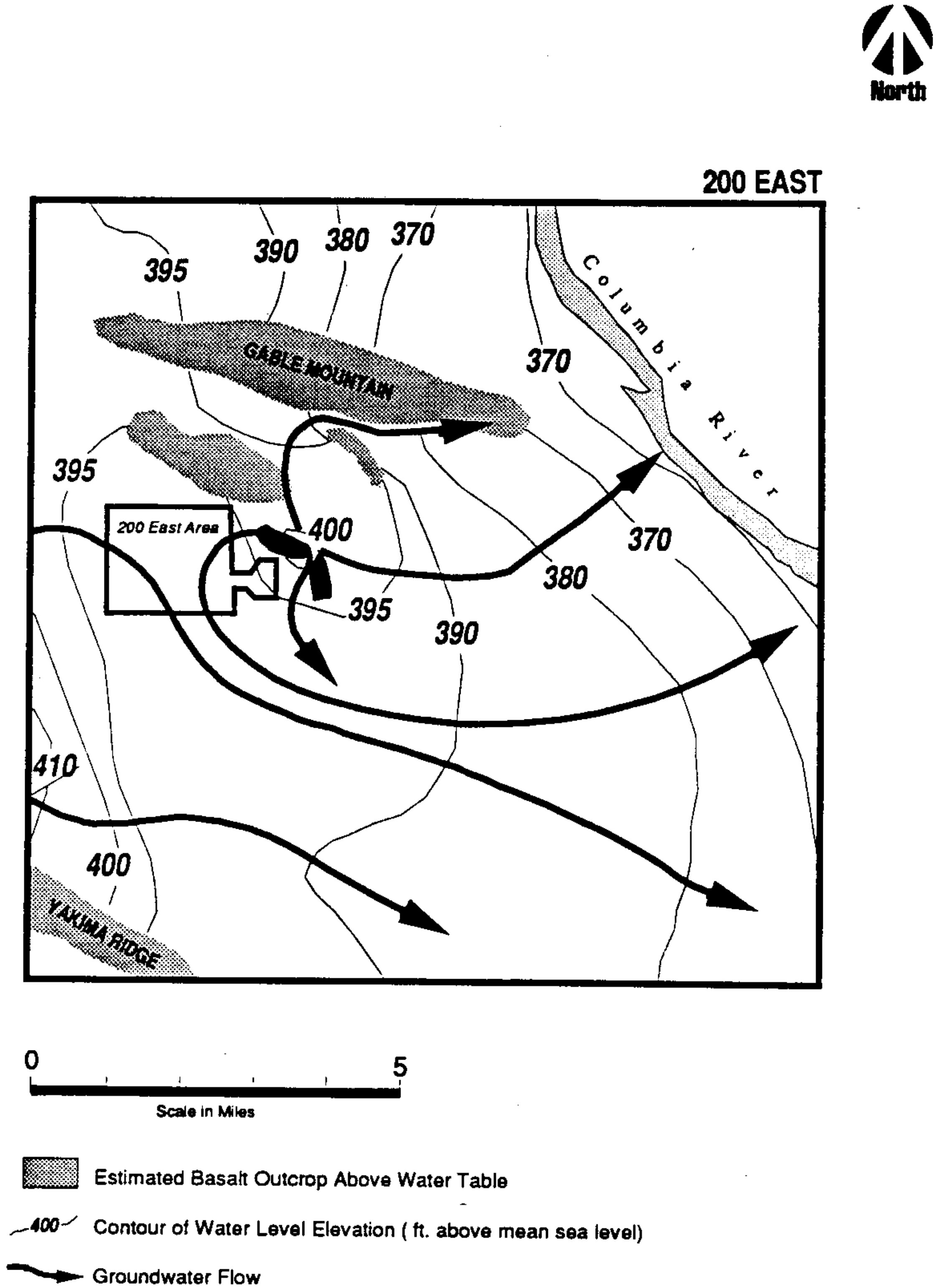


Figure 3-9. Water Table and Groundwater Flow in the Region of the 200 East Area for 1944



Source: Modified from Kipp and Mudd, 1974

Figure 3-10. Water Table and Groundwater Flow in the Region of the 200 East Area for 1955



Source: Modified from Kipp and Mudd, 1974

Figure 3-11. Water Table and Groundwater Flow in the Region of the 200 East Area for 1965

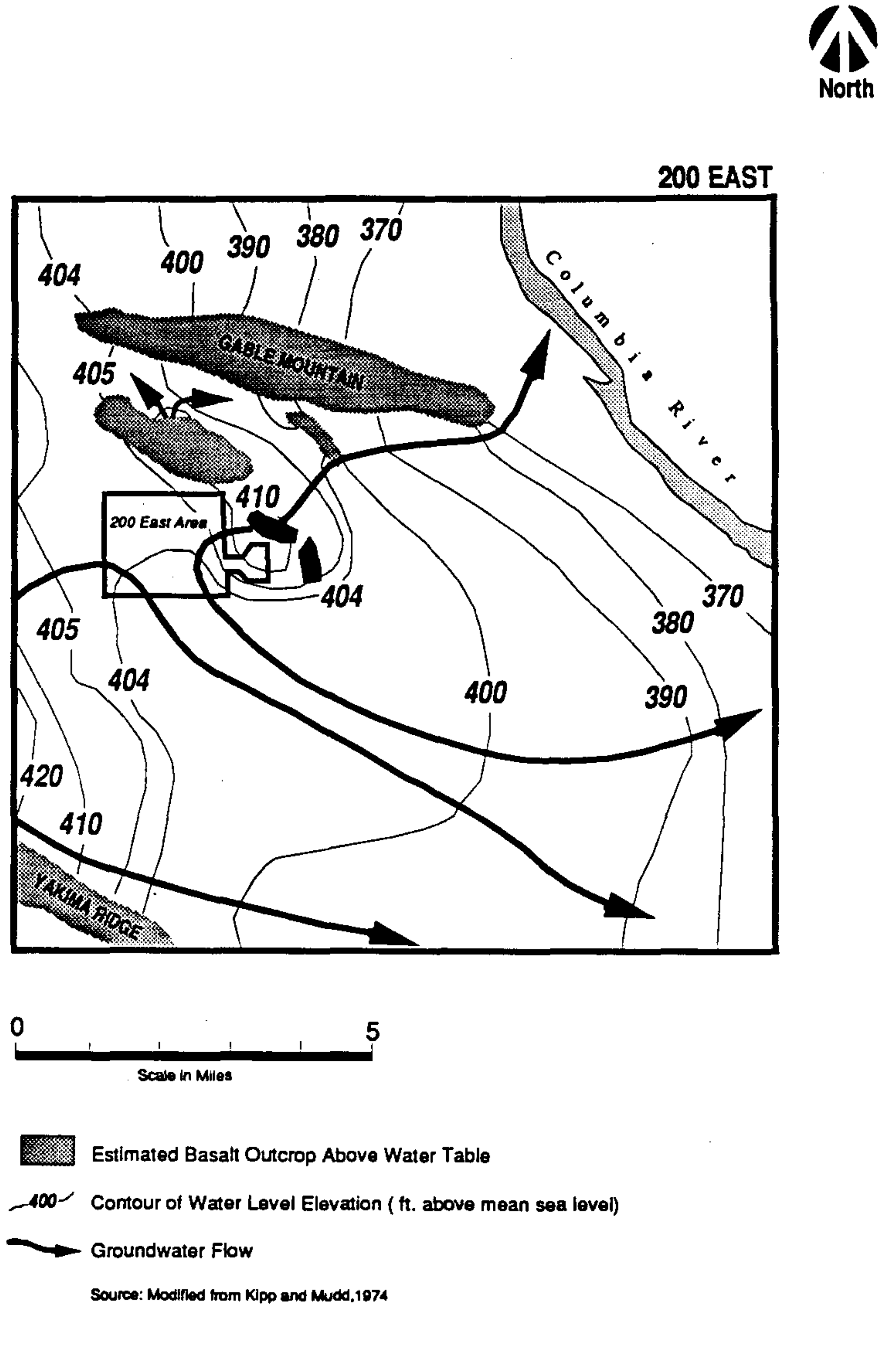


Figure 3-12. Water Table and Groundwater Flow in the Region of the 200 East Area for 1970

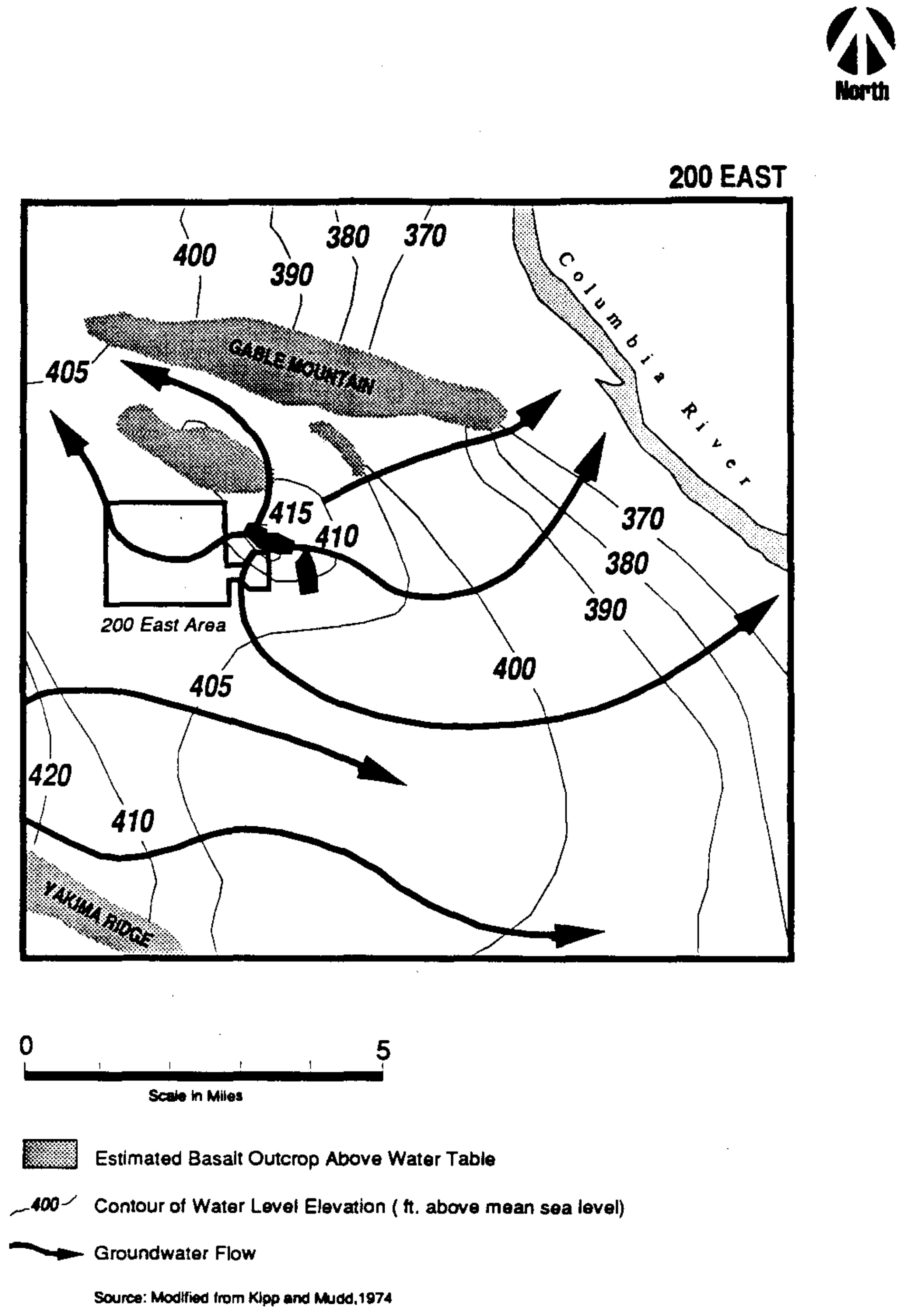
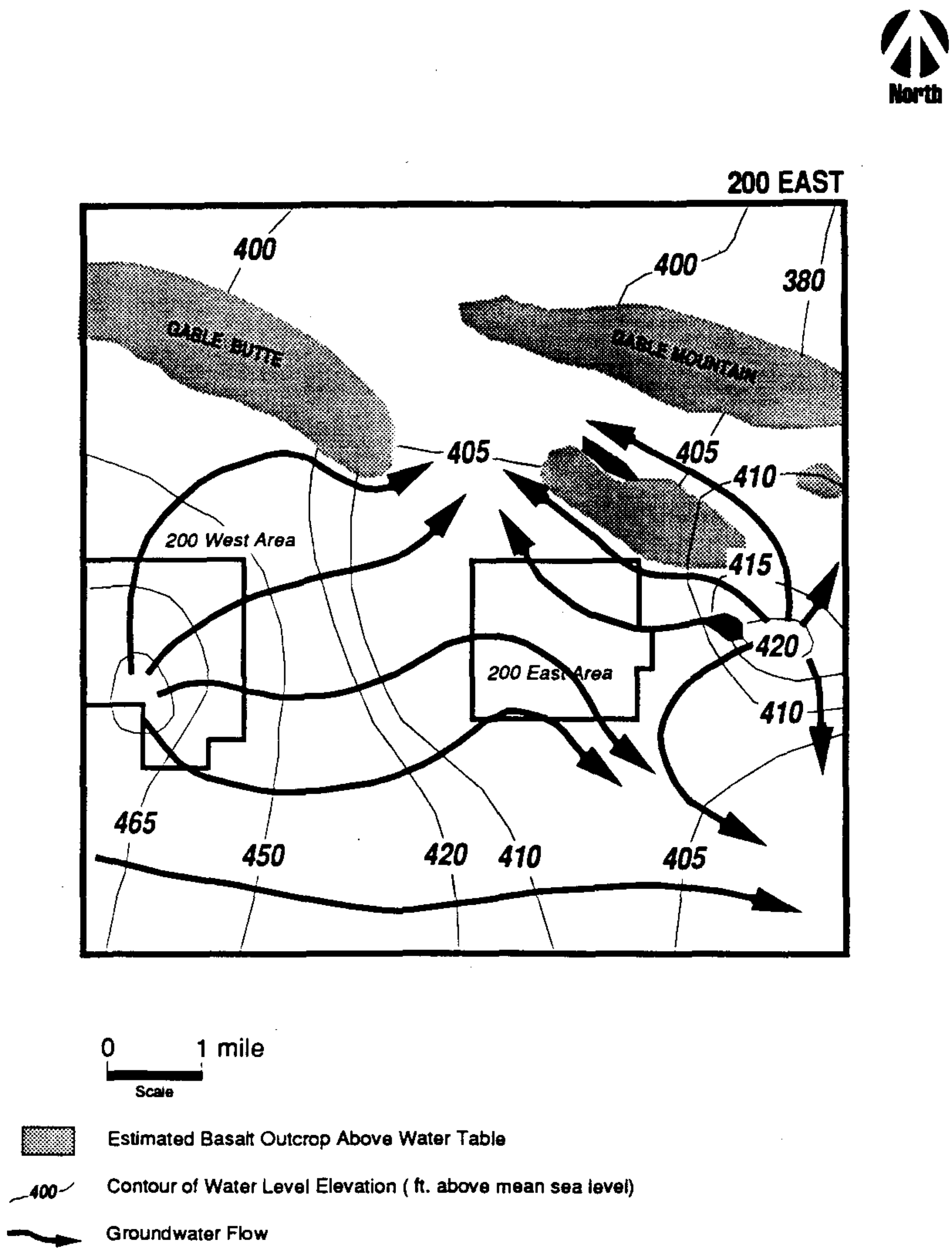


Figure 3-13. Water Table and Groundwater Flow in the Region of the 200 East Area for 1987



Source: Modified from Schatz and Ammerman 1988

Figure 3-14. Water Table and Groundwater Flow in the Region of the 200 East Area for June 1991

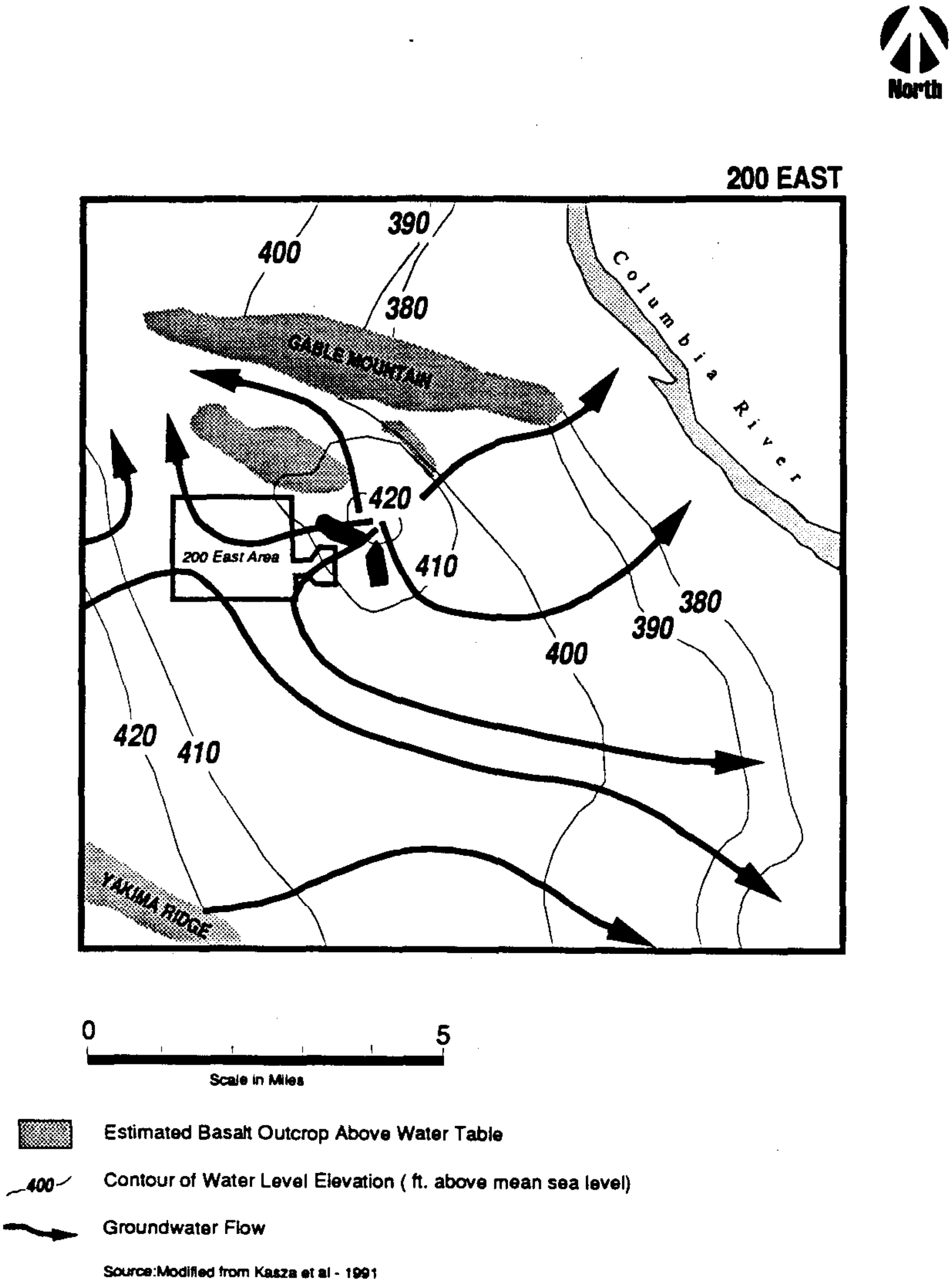
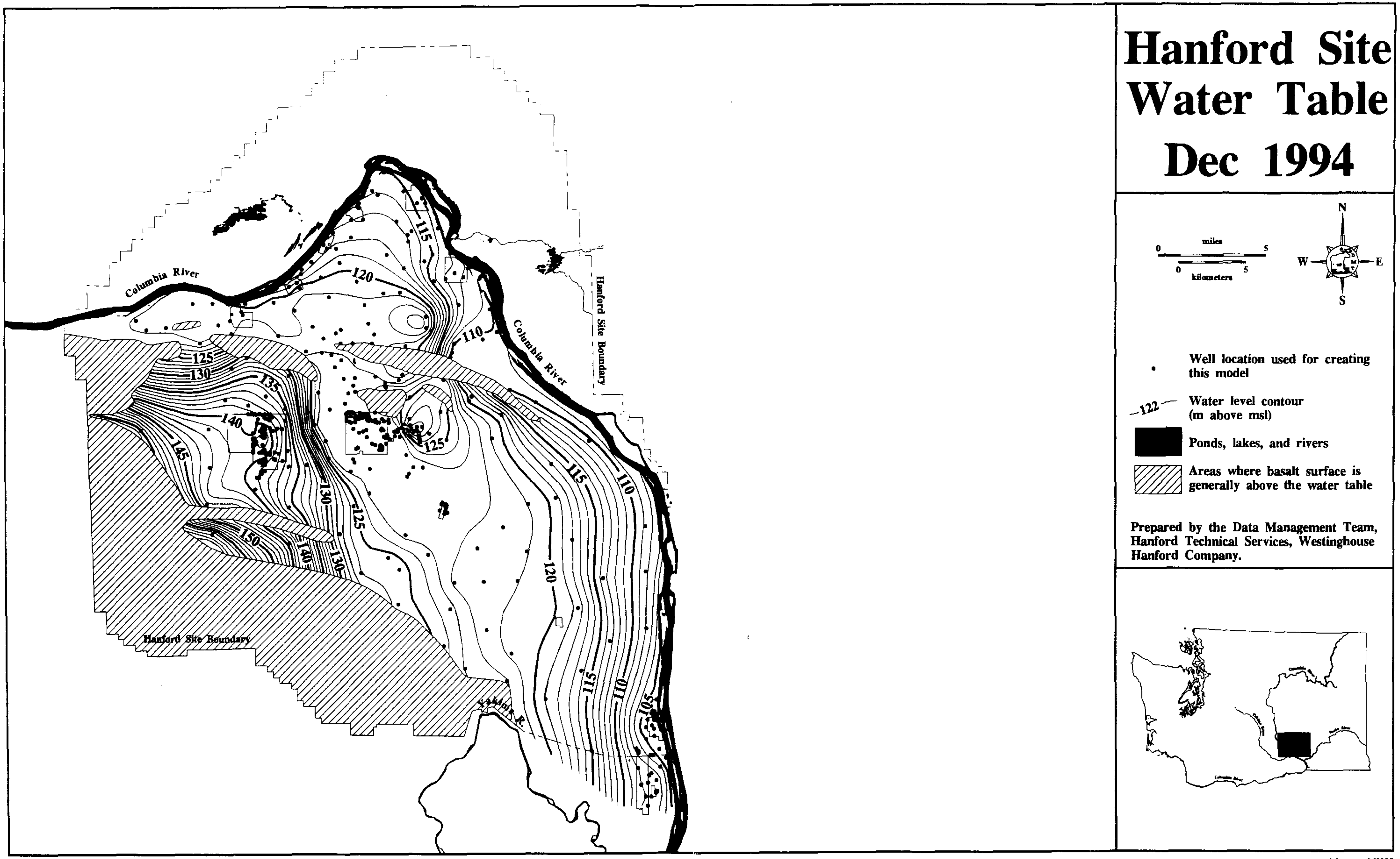


Figure 3-15. Hanford Site Water Table Map - December 1994



wl_hs.map-062895

Figure 3-16. Hydraulic Conductivity Map for the 200 East Area

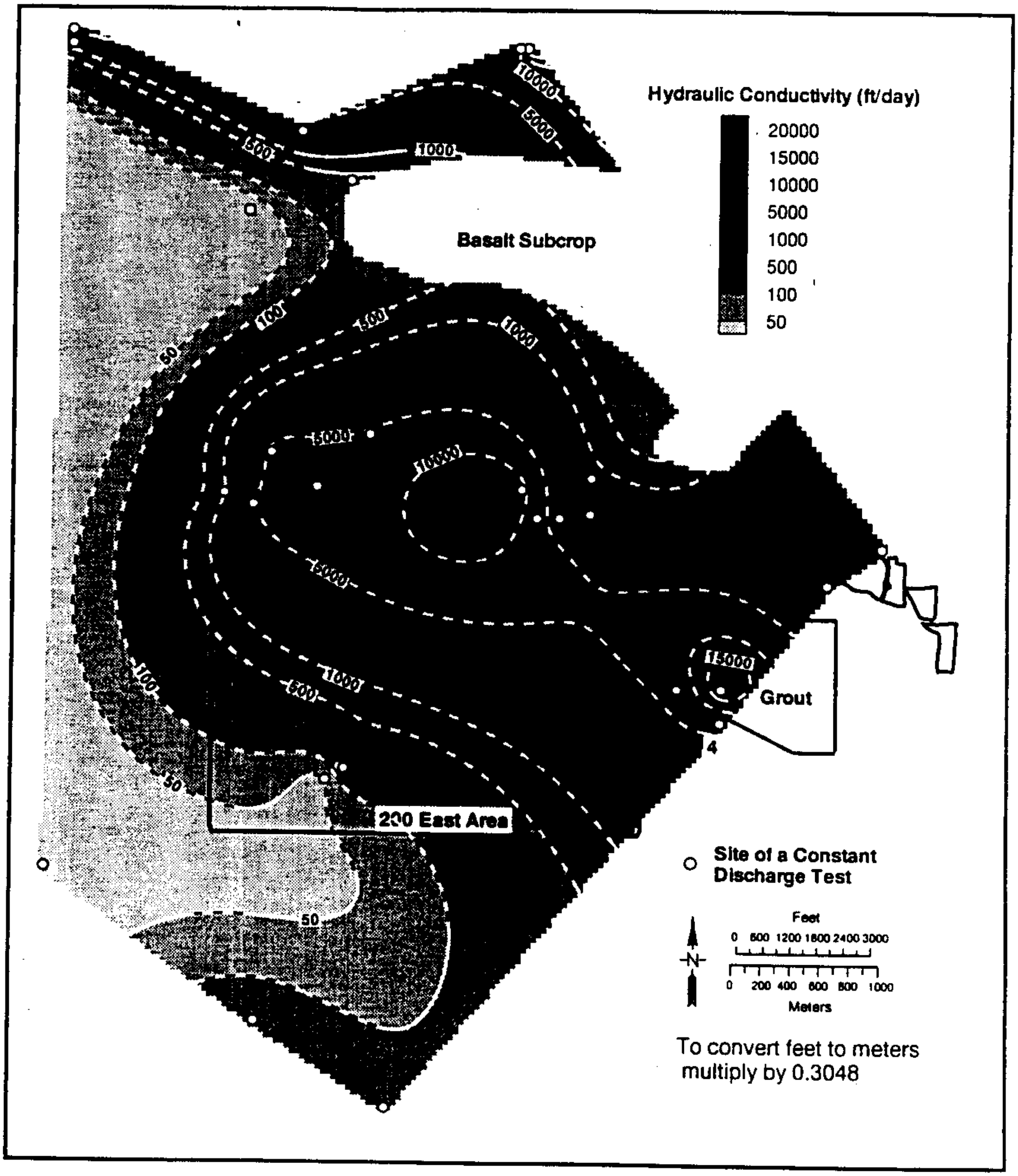


Figure 3-17. Potentiometric Surface Contour Map for the Unconfined and Rattlesnake Ridge Aquifers

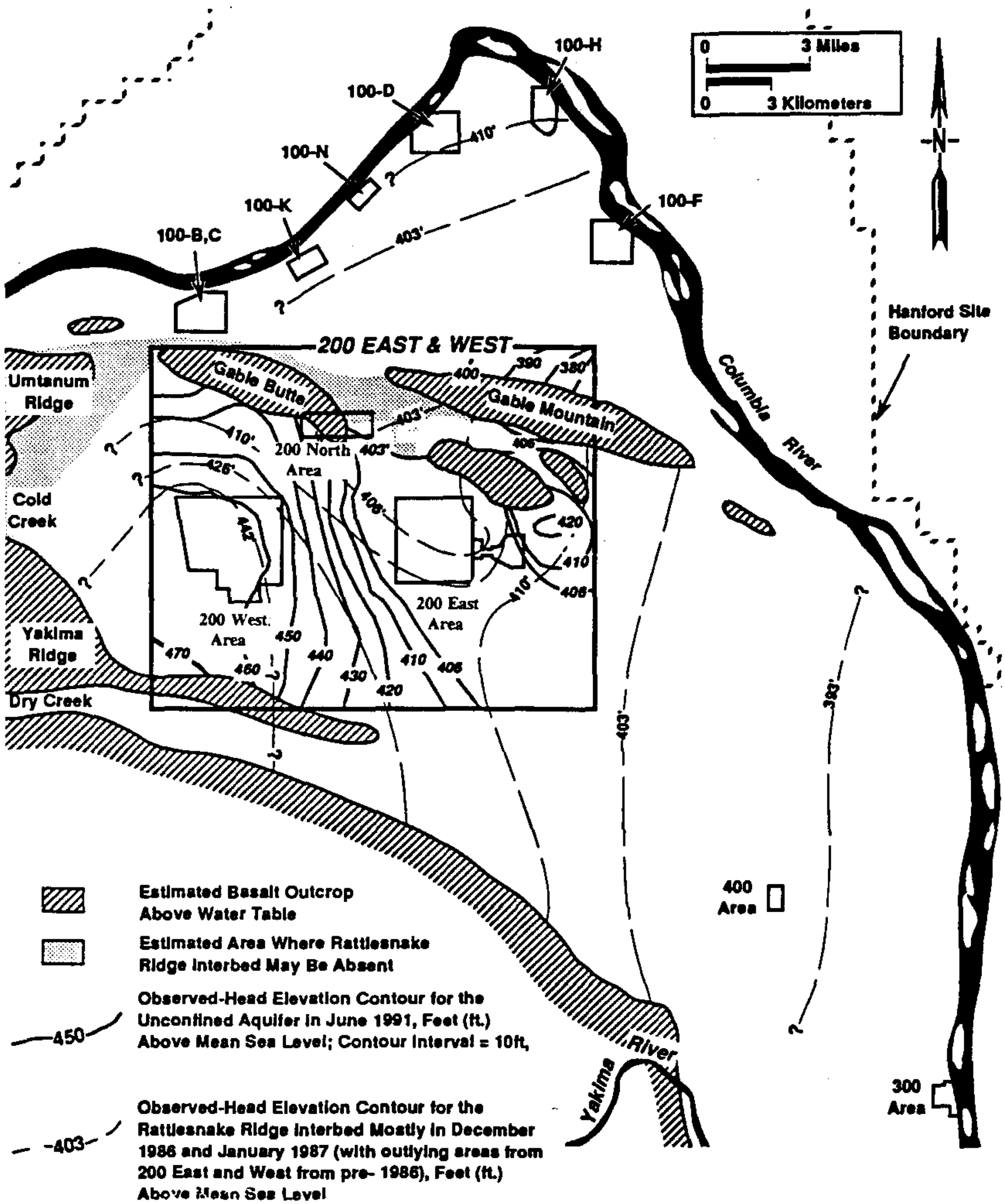


**Table 3-1. Unconfined Aquifer Properties
200 East Area RCRA Sites**

RCRA Site	Hydraulic Conductivity (m/d [ft/d])	Hydraulic Gradient	Effective Porosity	Flow Velocity[a] (m/d [ft/d])	References
2101-M Pond	45 (150)	0.0005	0.15	0.15 (0.5)	Chamness 1990
A-36B	150-300 (500-1000)	0.0001-0.0002	0.25	0.06-0.2 (0.2.-0.8)	WHC 1993
A-10	150-300 (500-1000)	0.0001-0.0002	0.25	0.06-0.2 (0.2-0.8)	WHC 1993
A-29	18.29 (60)	0.002-0.0003 0.0003-0.002	0.25	0.02 (0.07) So end 0.15 (0.48) No end	Kasza et al. 1992
Grout Treatment Facility	304.8 (1000)	0.000075	0.25	0.09 (0.3)	DOE-RL 1994
A-AX Tank Farm	33.5 (110)	0.0004	0.10 - 0.20	0.13 - 0.07 (0.44 - 0.22)	DOE-RL 1994
	21.3 (70)	0.0004	0.10 - 0.20	0.085 - 0.04 (0.28 - 0.14)	DOE-RL 1994
	7.3 (24)	0.0004	0.10 - 0.20	0.03 - 0.01 (0.05 - 0.1)	DOE-RL 1994
B-Pond	<u>Hanford fm</u> 640 (2100) <u>Ringold fm</u> 1.5 (5)	0.004-0.006 0.004-0.006	0.1-0.3 0.1-0.3	0.01-38.4 (0.03-126) 0.02-0.09 (0.07-0.03)	DOE-RL 1994
TEDF	.39 (1.3) 2.71 (8.9)	0.002 0.002	0.56 0.22	0.002 (0.005) 0.02 (0.008)	Davis et al. 1993
NRDWL	<u>Hanford fm</u> 610-1524 (2000-5000) <u>Ringold fm</u> 40 - 60 (130 - 200)	0.0001 0.0001	0.1 0.1	0.61 - 1.52 (2-5) 0.04 - 0.61 (.13 - 2)	Weekes et al. 1987

[a] Calculated using $v = Ki/n$, where K = hydraulic conductivity, i = gradient, and n = effective porosity

4.0 NATURE AND EXTENT OF CONTAMINATION

Waste generating processes in the 200 East Area, primarily associated with the operation of the PUREX and B Plants have contributed contaminants to the soil and groundwater. Liquid wastes potentially containing radionuclides, heavy metals and organic solvents were disposed of to waste sites such as ponds, cribs, and trenches. Some of these contaminants have migrated to the underlying groundwater within the 200-PO-1 Operable Unit.

4.1 SOURCES OF CONTAMINATION

The PUREX plant operated from 1955 to 1972, again from 1983 to 1988, and was then taken out of service in 1992. High-activity mixed wastes (radioactive and chemical constituents) were disposed of in eight tank farms, six of which are above 200-PO-1. Low-activity mixed wastes and other wastes were disposed directly to the soil in 23 cribs, four trenches and 15 french drains.

Impacts on 200-PO-1 from B-Plant activities are primarily related to the 216-B-3 Pond Complex (B-Ponds and Ditches) which received steam condensate, process cooling water, chemical sewer waste, and acid fractioner condensate from B-Plant operations. The B-Ponds began receiving liquid waste in 1945. Three lobes (A, B, and C) were added in the early 1980's. Significant groundwater mounding has occurred below B-Ponds resulting in alterations in groundwater flow in the 200 East Area. Groundwater mounding has receded since Lobe B was deactivated in 1985, and the main pond and Lobe A were deactivated and backfilled in 1994. Lobe C continues to receive non-dangerous cooling water effluent.

The BC Cribs and Trenches located in the southwest portion of the 200 East Area received liquid waste from U-Plant which is located in the 200 West Area. Six cribs and 20 trenches were used for direct soil disposal.

Other sources of contamination above the 200-PO-1 Operable Unit include: transportation, fabrication, and electrical maintenance shops; service stations; coal fired powerhouse, and the 2101-M pond. All of the waste sites above the 200-PO-1 Operable Unit are identified in Table 4-1.

4.2 POTENTIAL IMPACT TO GROUNDWATER

The depth to groundwater beneath liquid waste disposal sites within the 200 East Area is approximately 91 m (300 ft) bgs. Depth to groundwater decreases eastward toward the river. The driving force for contaminant migration from the disposal sites in 200 East Area is the disposal event itself. The current natural precipitation at the Hanford Site is approximately 16 cm (6.3 in) per year which does not result in significant mobilization of contaminants. The 200 East Groundwater AAMSR (DOE-RL 1992a) presents an evaluation of surface sites for potential migration to groundwater. This evaluation estimates possible groundwater impact by comparing vadose zone moisture retention capacity to the volume of liquids disposed. Those sites which disposed liquids of a volume greater than the capacity of the vadose zone were identified as having the potential to migrate to groundwater. From the sources identified previously, Table 4-2 identifies those sites which are considered to have a potential impact on groundwater. The constituents disposed of at these sites are identified in Table 4-3. Additional evaluation of impacts to groundwater will be conducted as part of the modeling and during the CMS.

4.3 DATA SCREENING

In order to identify constituents which are impacting groundwater quality, groundwater analytical data from 1984 to present were compiled for all wells associated with the 200-PO-1 Operable Unit.

The initial screening consisted of elimination of all analytes which had no detections from 1984 to present. The detections for the remaining analytes were then compared to potential levels of concern such as Federal MCLs (40 CFR 141.61), Washington State's MTCA Method B and C formula values, and other potential ARAR (Table 4-4). The comparison resulted in the identification of constituents potentially impacting groundwater quality.

Data from 1984 to present were gathered for each of the constituents potentially impacting groundwater. Data were eliminated from further consideration for the following reasons:

- Data point is the only detection in the well, or is the only detection exceeding MCL or MTCA-B formula values. Note that none of the most recent detections were eliminated.
- Detections exceed MCL/MTCA-B formula values historically, but are currently below levels of concern.
- Constituent was only sampled for once in an historical sampling event.
- Detections were qualified indicating lab/sample contamination problems, especially if other samples in the same sampling event had the same qualifiers.
- Historical detections of radionuclides which have decayed to concentrations below levels of concern.
- Detection is qualified as being above the instrument detection limit but below the contract required quantitation limit.
- Detection was from an unfiltered sample where filtered results are non-detects or below levels of concern.

The results of the screening are presented in Table 4-5.

4.4 WELL-SPECIFIC DATA TRENDING

Based on the data screening presented in Table 4-5, the following constituents have been retained for well-specific trend analysis:

- arsenic
- chromium
- iodine-129
- manganese
- strontium-90
- tritium
- vanadium
- nitrate.

Each constituent which exceeded levels of concern is evaluated by well specific trend analysis using concentration vs. time plots. The plots show concentrations since 1984 compared to levels of concern and background levels (Table 4-4). These plots identify wells that have constituents exceeding levels of concern and if the concentrations are increasing or decreasing relative to time. The well specific data trending aids in the definition of contaminant plumes and facilitates the definition of plume migration. The well specific trend and contaminant plume analyses are presented in the subsequent sections.

4.4.1 Arsenic

Arsenic was detected above levels of concern in eight wells. Each well and the associated range of arsenic concentrations are presented below:

Analytical Results (ppb)

Well	Filtered	Unfiltered
299-E18-4	11-15	9-16
299-E25-29P	10-13	7.7-14
299-E25-30P	15-16	12-46
299-E25-33	11-15	5-15
299-E25-35	9.3-15	5-17
299-E25-40	11-14	11-23
299-E25-46	11-15	10-13
699-43-42J	15-28	8-29

Well specific trends are as follows:

<u>299-E25-29P</u> - Figure 4-1 shows concentrations are consistently above MTCA B and C standards (0.05 ppb/0.5 ppb), and are slightly above the background value of 10 ppb.

299-E18-4 - Figure 4-2 shows concentrations are consistently above MTCA B and C standards, and are slightly above the background value of 10 ppb.

299-E25-30P - Figure 4-3 shows concentrations decreased dramatically from 1987 to 1989, then stabilized just above background of 10 ppb. All concentrations exceed MTCA B and C standards.

299-E25-33 - Figure 4-4 shows concentrations increased from below background to above background from 1987 to 1990. Concentrations have stabilized just above background of 10 ppb. All concentrations exceed MTCA B and C standards.

299-E25-35 - Figure 4-5 shows concentrations are consistently above MTCA B and C standards, and are slightly above the background value of 10 ppb.

299-E25-40 - Figure 4-6 shows concentrations are consistently above MTCA B and C standards, and are slightly above the background value of 10 ppb.

299-E25-46 - Figure 4-7 shows concentrations are slightly increasing with time above MTCA B and C standards, and are slightly above the background value of 10 ppb.

699-43-42J - Figure 4-8 shows concentrations are slightly increasing with time above MTCA B and C standards, and have been increasing to levels around 20 ppb.

The data from these wells indicate arsenic contamination is not associated with a specific TSD unit. Although concentrations exceed MTCA B and C levels of concern, they are very near the background value of 10 ppb.

As indicated on Figure 4-9, the arsenic plume is primarily confined to the 200 East Area and does not extend off the central plateau. Arsenic is a fairly mobile constituent with potential to eventually migrate off-plateau. However, the current concentrations of arsenic are only slightly elevated over the background concentration (10 ppb). Because the arsenic levels are fairly consistent throughout, the arsenic is probably not statistically elevated over background. Impacts from movement of the arsenic plume are considered negligible because the contaminant concentrations will decrease through dispersion of the plume.

4.4.2 Chromium

Chromium was detected above levels of concern in only one well (299-E24-19). Analytical results ranged from 60 to 1800 ppb (filtered) and 74 to 3000 ppb (unfiltered). Figure 4-10 shows that chromium concentrations peaked in late 1992 but have since decreased. Recent sampling indicates that filtered concentrations are at or below the MTCA B standard of 80 ppb. This well is associated with the RCRA Monitoring Well network for A-AX tank farms. It appears that the chromium contamination is related to that TSD facility and is not common to the 200-PO-1 Operable Unit. The chromium plumes for the Hanford Site are shown on

Figure 4-11. The chromium contamination in the 200-PO-1 Operable Unit is not wide spread enough to show up as a plume.

4.4.3 Iodine 129

Detections in many wells exceed the MCL of 0.48 pCi/ℓ but are below the proposed MCL of 21 pCi/ℓ. Because the Iodine-129 detections are so prevalent in the operable unit, no trend analysis has been performed. Instead a plume map for Iodine-129 has been developed.

As indicated on Figure 4-12, the iodine-129 plume has migrated beyond the 200 East Area and off the central plateau. Iodine-129 plume with concentrations below the regulatory standard has reached the Columbia River in the past from an early phase of operations in the 200 East Area. Later operations resulted in another plume of iodine-129 which is currently migrating towards the river. The concentrations of the iodine-129 are only slightly elevated above the current MCL of 0.48 pCi/L; the concentrations are well below the proposed MCL of 21 pCi/L (55 FR 33050). Iodine-129 is a mobile, long-lived radionuclide; therefore, natural decay is not a significant factor in reduction of the concentrations. The iodine-129 will continue to move towards the river; however, dispersion and mixing will further reduce concentrations.

4.4.4 Manganese

Manganese was detected above levels of concern in five wells. Each well and the associated range of manganese concentrations are presented below:

Analytical Results

Well	Filtered	Unfiltered
699-40-36	83-160 ppb	87-780 ppb
699-40-40B	130-300 ppb	130-640 ppb
699-41-35	85-170 ppb	130-210 ppb
699-42-39B	57-630 ppb	110-660 ppb
699-46-E4B	111 ppb	86 ppb

The concentration vs time plots for manganese indicate the following contaminant trends:

699-40-36 - Figure 4-13 shows manganese concentrations for filtered data have remained stable since 1992. The concentrations fall above the MTCA B cleanup standards of 80 ppb but below the MTCA C standard of 175 ppb.

699-40-40B - Figure 4-14 shows concentrations have decreased over time from 1991 to present. Previous sampling indicates concentrations exceed the MTCA C standard of 175 ppb. Recent sampling indicates that concentrations are below the MTCA C standard but still above the MTCA B standard.

699-41-35 - Figure 4-15 shows concentrations have decreased since 1992. Levels indicated are below the MTCA C standard of 175 ppb and approaching the MTCA B standard of 80 ppb.

699-42-39B - Figure 4-16 shows concentrations have been decreasing since 1991. From 1991 to 1993 concentrations exceeded the MTCA C standard of 175 ppb but recent sampling indicates concentrations have dropped below the MTCA B standard of 80 ppb.

699-S6-E4B - Only two data points are available therefore no trend plot was developed. Concentrations exceed the MTCA B standard of 80 ppb but are below the MTCA C standard of 175 ppb.

The contamination has been identified in wells associated with the RCRA monitoring program for the 216-B-3 pond system, therefore, manganese contamination is considered to be associated with that TSD facility and not common to the 200-PO-1 Operable Unit. With few detections in a small number of wells, no plume map has been developed.

4.4.5 Strontium 90

Strontium-90 has been detected above levels of concern in only two wells. Each well and the associated range of strontium-90 concentrations are presented below:

Well	Analytical Results (pCi/ℓ)
299-E17-14	14.1-28.1
299-E17-15	6.56-12.7

299-E17-14 - Figure 4-17 shows concentrations are stable above the MCL of 8 pCi/ℓ. The concentrations are consistently near two times the MCL but are well below the proposed MCL of 42 pCi/ℓ.

299-E17-15 - Figure 4-18 shows concentrations have increased slightly from below the MCL of 8 pCi/ℓ to above the MCL at approximately 13 pCi/ℓ. The concentrations are well below the proposed MCL of 42 pCi/ℓ.

The contamination is associated with wells which are part of the RCRA monitoring network for the 216-A-36B TSD facility. It appears that the strontium-90 contamination is associated with this facility only and is not common to the 200-PO-1 Operable Unit. Figure 4-19 shows that the strontium-90 plume is confined to the 200 East Area.

4.4.6 Tritium

Detections in a large number of wells exceed the MCL of 20,000 pCi/ℓ. Because the tritium detections are so prevalent in the operable unit, no trend analysis has been performed. Instead a plume map for tritium has been developed.

As indicated in Figures 4-20 and 4-21, the tritium plume extends beyond the central plateau and has reached the Columbia River. A higher concentration plume associated with earlier operations reached the river in approximately 15-20 years. Currently, a second higher concentration plume related to later operations is moving across the plateau towards the river and is expected to reach the river in a similar timeframe. Information on the Columbia River springs is presented in Section 4.5.

4.4.7 Vanadium

Vanadium was detected above levels of concern in only one well (299-E25-23). Analytical results ranged from 123 to 145 ppb (filtered) and 139 ppb (unfiltered). Figure 4-22 shows that concentrations exceed the MTCA B value of 112 ppb, but are well below the MTCA C value of 245 ppb. Additionally, the most recent analytical data is from 1990; therefore, current concentrations are not known. The contamination appears to be down gradient from the 216-A-37-2 crib and is not prevalent throughout the operable unit. No plume map has been developed.

4.4.8 Nitrate

Nitrate has been detected in many wells at levels exceeding MTCA B and C as well as the Federal MCL. Because the nitrate detections are so prevalent in the operable unit, no well-specific trend analysis has been performed. Instead a plume map for nitrate has been developed.

As indicated on Figure 4-23, the nitrate above 20,000 ppb is present in a plume very similar in shape and extent to the tritium plume. The nitrate concentrations above the MCL of 45,000 ppb tend to occur as small, isolated plumes and may represent slugs of contamination related to historical disposal events. Nitrate is a mobile contaminant and has reached the river at concentrations above MCL. The slugs of nitrate above 45,000 ppb may eventually reach the river; however, the historical plume maps do not indicate much movement in the past few years (Figure 4-24). The concentrations will also be reduced through mixing with lower concentration groundwater as they move towards the river.

4.5 COLUMBIA RIVER SPRING EVALUATION

This section summarizes existing water quality data from the springs discharging to the Columbia River which may be impacted by the 200-PO-1 Groundwater Operable Unit. Specifically, this area of interest on the Columbia River is known as, Hanford river miles (HRM) 28 to 42 (Figure 4-25). To ensure that all relevant data is incorporated into this report, including background and dispersion information for the 200-PO-1 plume, HRM 26 to 44 were evaluated. Hanford river miles are the approximate distance in miles downstream from the Vernita Bridge on the Columbia River.

The following reports were reviewed and summarized for pertinent characterization data:

- *1988 Hanford Riverbank Springs Characterization Report* (Dirkes 1990)
- *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hans 1995).

4.5.1 1988 Hanford Riverbank Springs Characterization Report

The *1988 Hanford Riverbank Springs Characterization Report* (Dirkes 1990) presents the results of a study undertaken to characterize the Hanford riverbank springs/seepage. Radiological and nonradiological analyses were performed. Extensive radiological sampling was conducted in thirteen springs of interest. In addition, three near-river springs river radiological samples were taken. The number of springs sampled was minimal for the non-radiological components (those springs were chosen that were known to have non-radiological contaminants), but the analysis was extensive. Non-radiological samples were analyzed for 289 different chemicals, in three springs of interest, including all dangerous waste constituents as identified by the State of Washington in Washington Administrative Code (WAC) 173-303-9905. Tables 4-6 and 4-7 show the 1988 sampling results, as discussed here, within the 26 through 44 HRM area. The associated radionuclide regulatory levels of concern are presented on Table 4-8 and the non-radionuclide regulatory levels of concern are on Table 4-9.

River water samples were also analyzed from upstream and downstream of the Site. In addition, irrigation return water and spring water entering the river along the shoreline opposite Hanford were analyzed.

4.5.2 Hanford Site Environmental Report for Calendar Year 1994

Hanford Site Environmental Report for Calendar Year 1994 (Dirkes and Hans 1995), cites specific radiological data in the old Hanford Townsite and 300 Area spring and cross sectional river water. However, the report does not provide the same information for non-radiological contaminants. The non-radiological contaminants are named if they violate any known regulatory levels (which are provided), however; complete non-radiological sampling data are not provided. The report does show selected trending results from 1989 through 1994 for riverbank springs contamination from the Hanford Site to the Columbia River.

As a special note, the report mentions that the Hanford Reach (which includes this study's area of interest at HRM 26 through 44) of the Columbia River has been designated as Class A (Excellent) waters, which requires that the water be usable for substantially all needs including drinking water, recreation, and wildlife.

4.5.2.1 Old Hanford Townsite. The Old Hanford Townsite springs are located at approximately 27 through 30 HRMs. Table 4-10 shows the 1994 Hanford Site radionuclide concentrations measured in Columbia riverbank spring water and near-springs Columbia River water along specific cross sections at the old Hanford Townsite.

4.5.2.2 300 Area. The 300 Area Springs are located at approximately 41.8 through 42.6 HRMs. Table 4-11 shows the 1994 Hanford Site radionuclide concentrations measured in Columbia riverbank spring water and near-spring Columbia River water along specific cross sections at the 300 Area.

4.5.3 Summary of Spring Evaluation

Based upon the review of reports discussed above, and consideration of potential regulatory levels of concern, the following discusses potential contaminants in the springs. The primary objective of the spring evaluation is to determine the impacts, if any, that the 200-PO-1 groundwater has had on Columbia River springs; therefore, conclusions are presented which discuss the relationship between 200-PO-1 COPC and COPC in the springs.

The *1988 Hanford Riverbank Springs Characterization Report* (Dirkes 1990) stated that the type and concentrations of contaminants in the riverbank springs along the Hanford shoreline are within the range known to exist in the groundwater near the river. The report confirmed that the 200 Area groundwater plume has expanded as expected and is now discharging into the river farther south than previously observed, nearly to the northern edge of the 300 Area. Tritium, while below current DOE Derived Concentration Guides (DCG) (Table 4-8), was detected at concentrations above the current Federal MCL (Table 4-8) in several spring and river samples of interest, including Spring 27.5, River 27.5, Spring 28.1 (1st of 2 samples taken), Spring 28.1 (2nd of 2 samples taken), River 28.1 and Spring 28.5 HRMs. In addition, beta in Spring 28.1 (1st of 2 samples taken) was above the assumed compliance of Federal MCLs. All other radionuclide concentrations were below current regulatory levels identified in Table 4-8.

Of the 289 nonradiological contaminants tested, only twenty were above the laboratory detection level for the spring and river samples of interest. Three contaminants, in Spring 28.1 were of regulatory concern: 1) aluminum was within the Federal and Washington State Secondary MCL range (Table 4-9) , 2) iron was over the Federal and Washington State Secondary MCL (Table 4-9), and 3) nitrate was over the Federal and Washington State Primary MCLs (Table 4-9). In addition Nitrate sampled at River 28.1 was over the Federal and Washington State Primary MCLs (Table 4-9). Additionally, copper in Spring 42.1, and iron, cyanide, and nitrate in Spring 28.1, exceed their respective Ambient Water Quality Criteria (AWQC) presented in Table 4-12. All other nonradionuclide concentrations were below current regulatory levels identified in Table 4-9. The report concluded that spring discharges were very small relative to the flow of the Columbia River; therefore impact of groundwater discharges to the Columbia River were minimal.

The *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hans 1995) confirmed there were radiological and non-radiological contaminants in the old Hanford Townsite and 300 Area Springs in 1994. All radiological results from the riverbank springs in the old Hanford Townsite and 300 Area springs in 1994 were less than the DOE DCG (Table 4-8). However, both Federal and Washington State MCLs (Table 4-8) were exceeded by tritium concentrations along the old Hanford Townsite springs and total alpha in the 300 Area springs. All other radionuclide concentrations were below the regulatory levels identified in Table 4-8.

All non-radiological contaminant concentrations measured in the old Hanford Townsite and 300 Area riverbank springs were below the primary Federal and Washington State Drinking Water Standards in 1994 (Table 4-9). However, iron in the 300 Area springs and aluminum, iron, and manganese in the old Hanford Townsite Springs exceeded the secondary Federal and Washington State Drinking Water Standards in 1994 (Table 4-9). All other non-radionuclide concentrations were below the regulatory levels identified in Table 4-9.

Trending at the old Hanford Townsite showed that in 1994 total beta and technetium-99 concentrations were lower than those observed during recent years, while tritium concentrations exhibited a wide fluctuation with the highest concentration still within the range normally observed. From 1989 through 1994, tritium concentrations were elevated in the 300 Area riverbank spring samples, which reflects the expansion of the contaminated groundwater plume emanating from the 200 Areas. Total uranium, total alpha and total beta concentrations discharged to the Columbia River near the 300 Area has also increased in recent years. Overall, contaminant trending results from 1994 were comparable to previous years.

Of the potential contaminants identified in the springs (tritium, gross beta, aluminum, iron, nitrate, copper, cyanide, total alpha, and manganese) only tritium, nitrate, and manganese are COPC in the 200-PO-1 groundwater. Tritium and nitrate in 200-PO-1 groundwater are very likely impacting the springs given the location of the contaminant plumes.

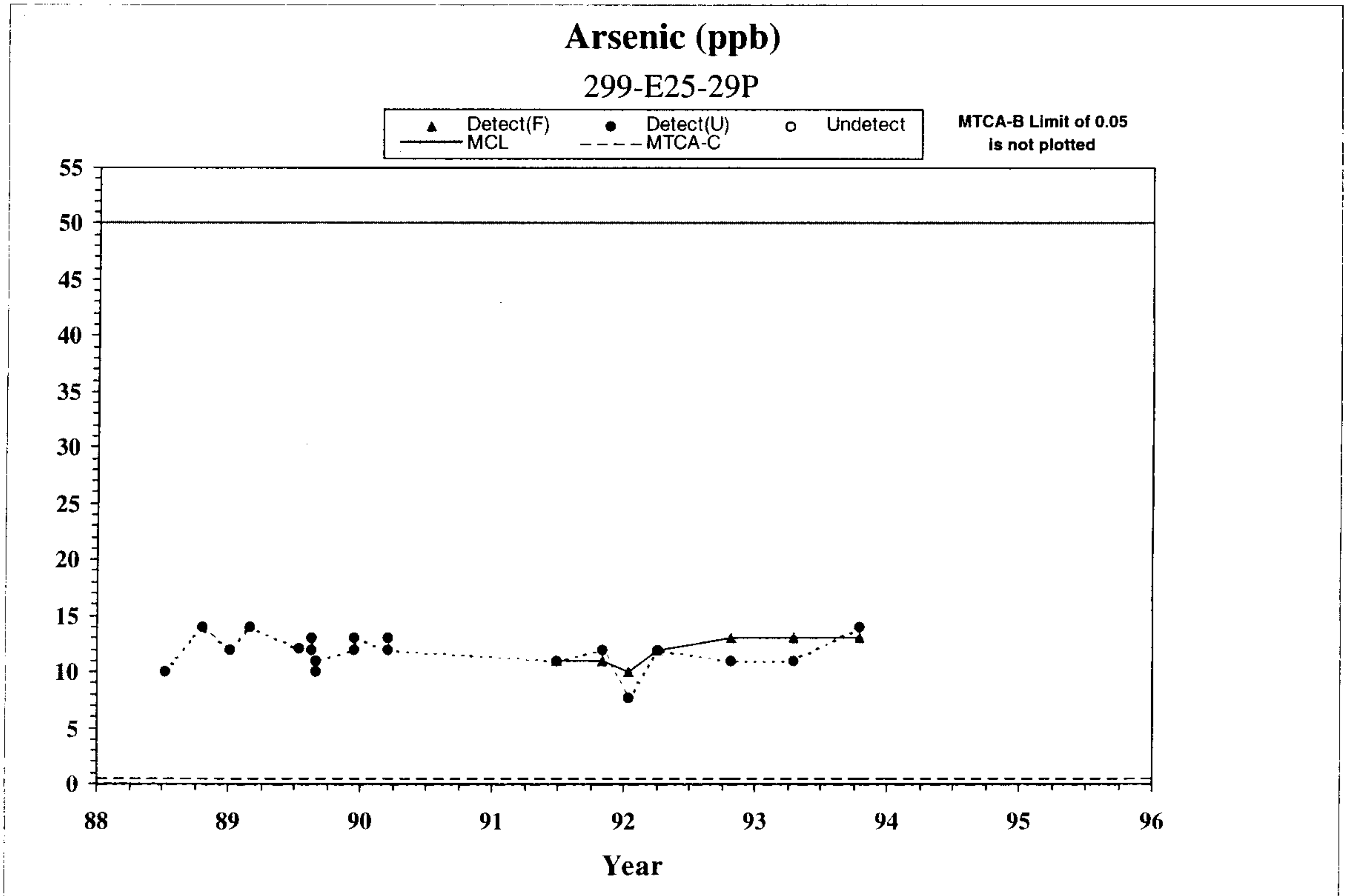


Figure 4-1. Arsenic Trend Analysis for Well 299-E25-29P

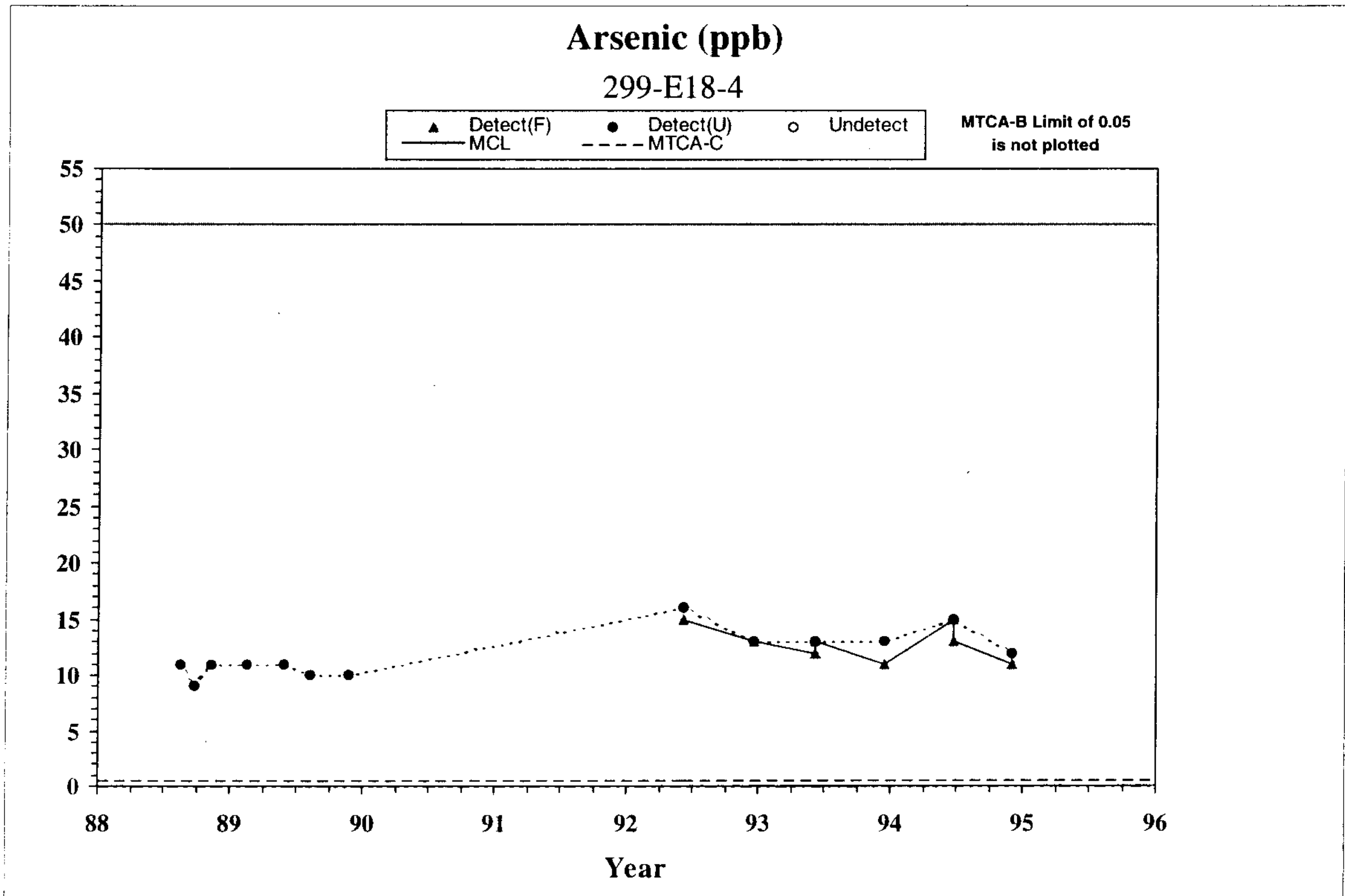


Figure 4-2. Arsenic Trend Analysis for Well 299-E18-4

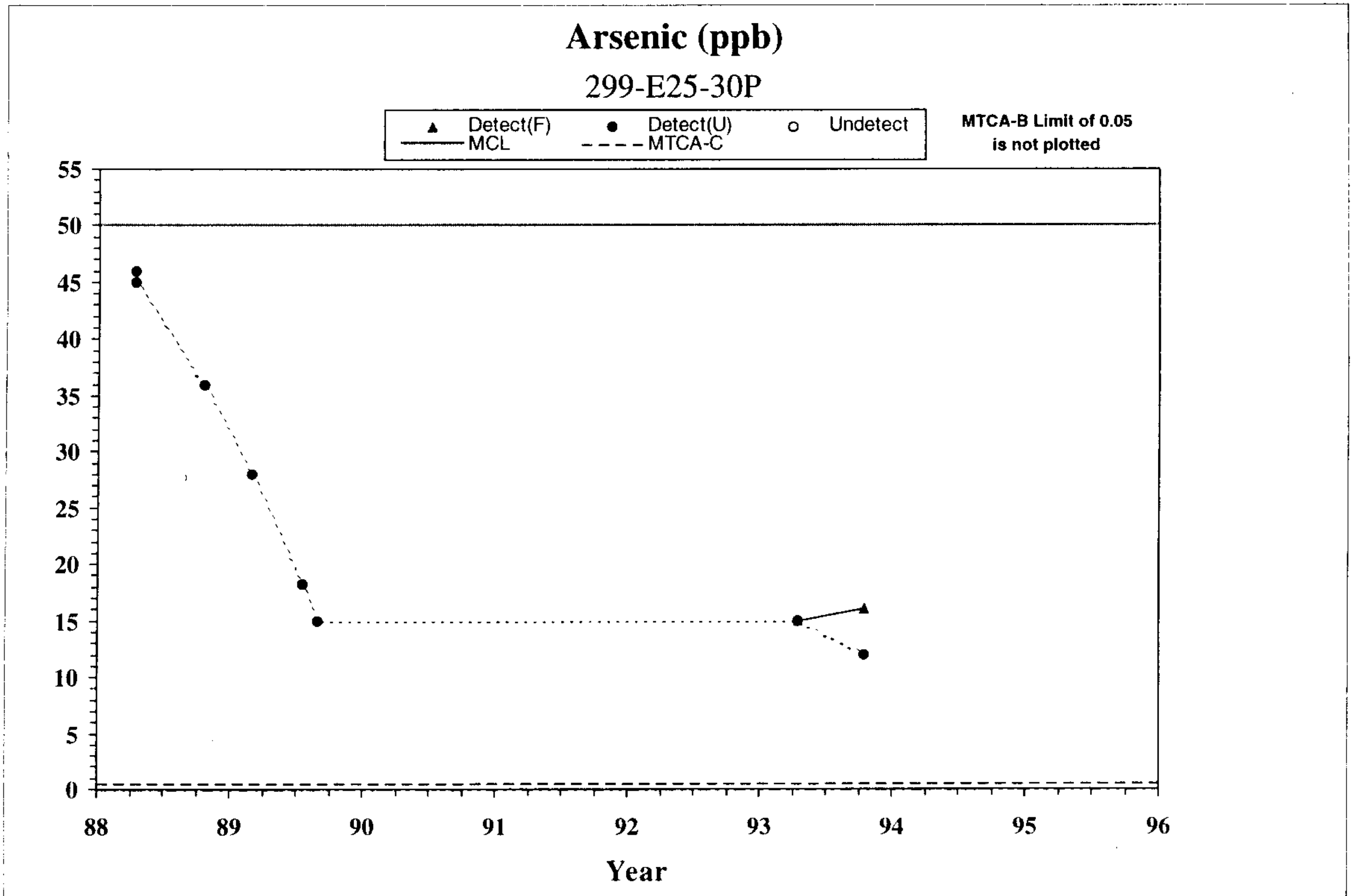


Figure 4-3. Arsenic Trend Analysis for Well 299-E25-30P

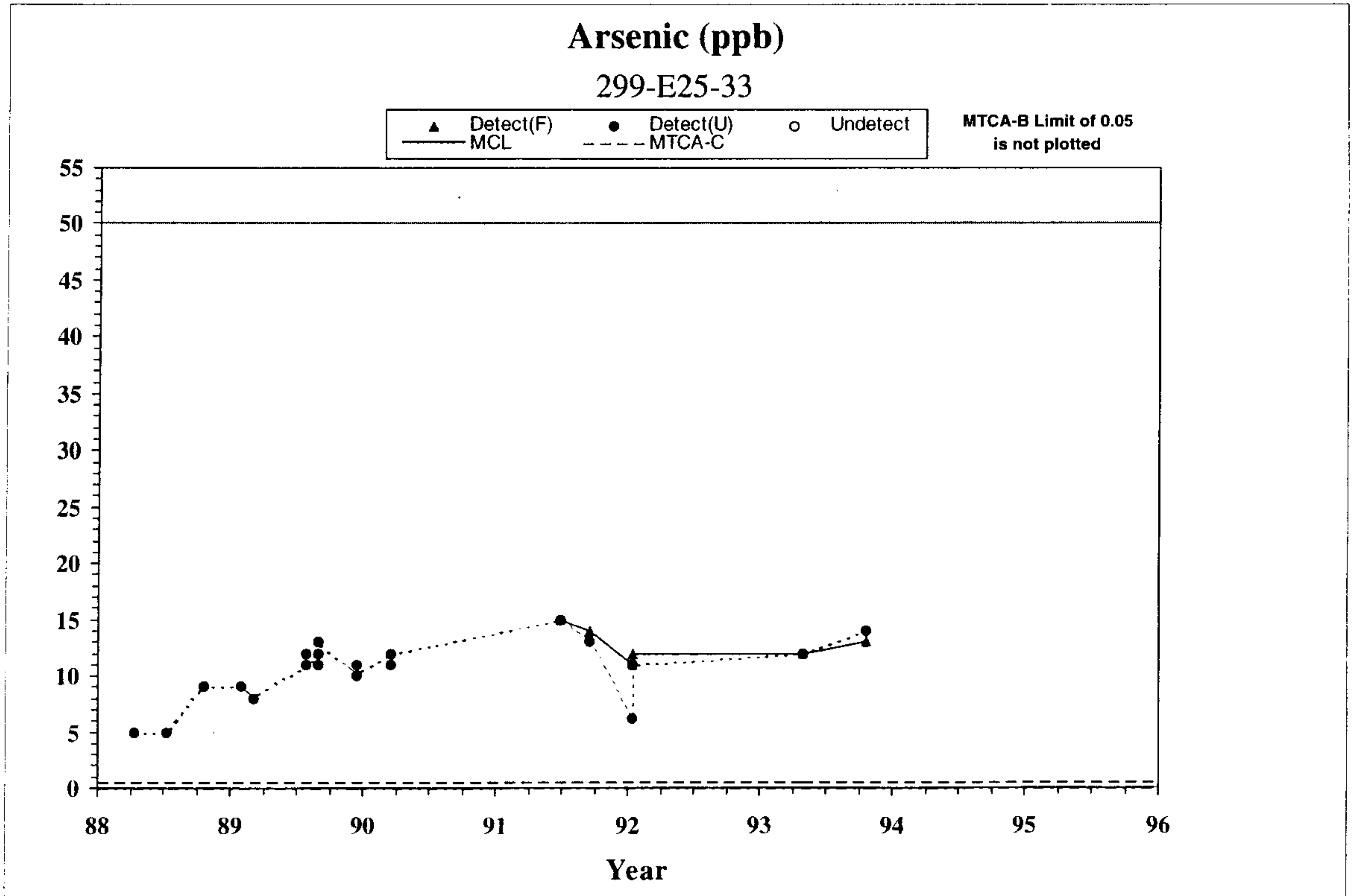


Figure 4-4. Arsenic Trend Analysis for Well 299-E25-33

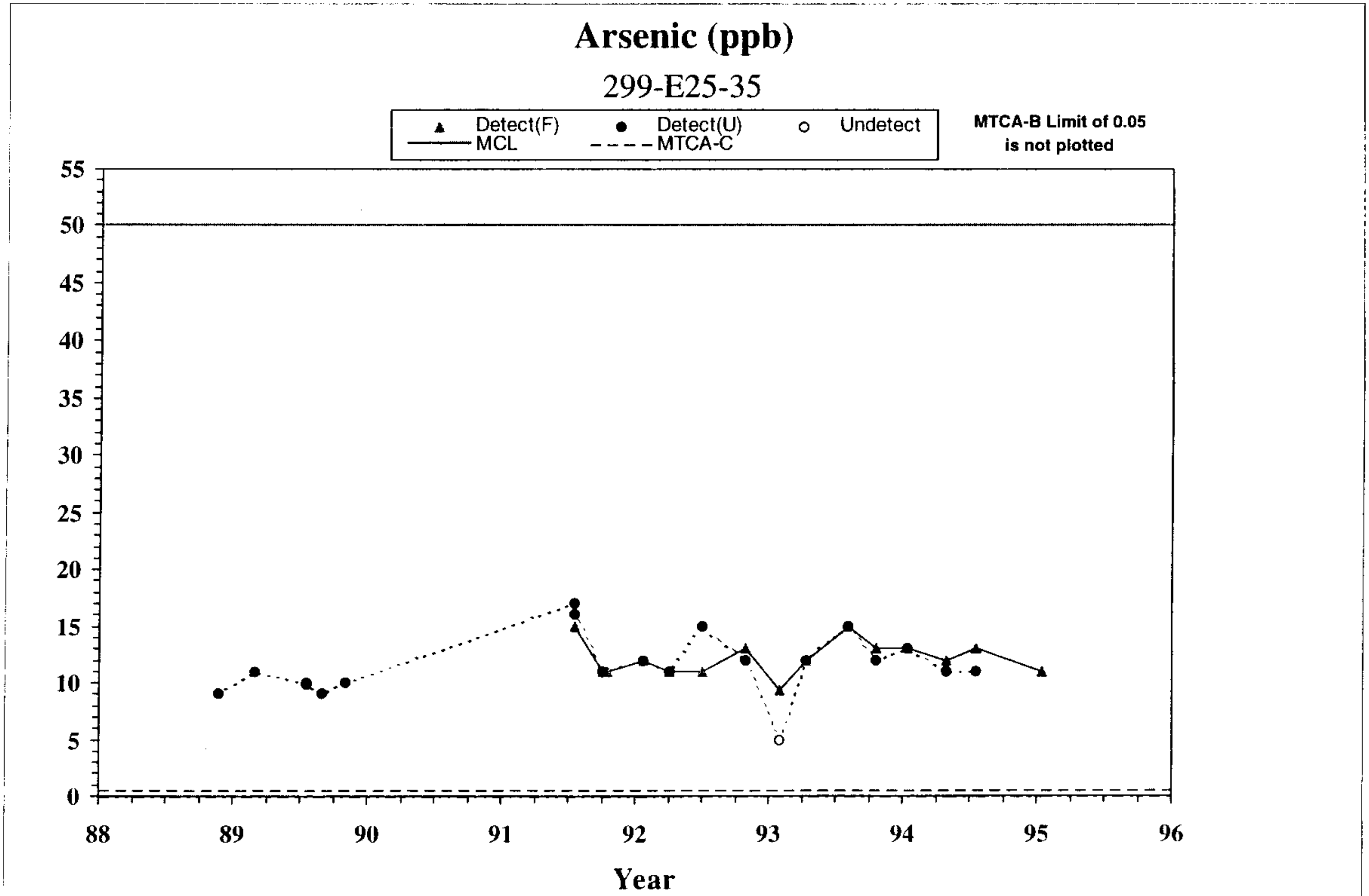


Figure 4-5. Arsenic Trend Analysis for Well 299-E25-35

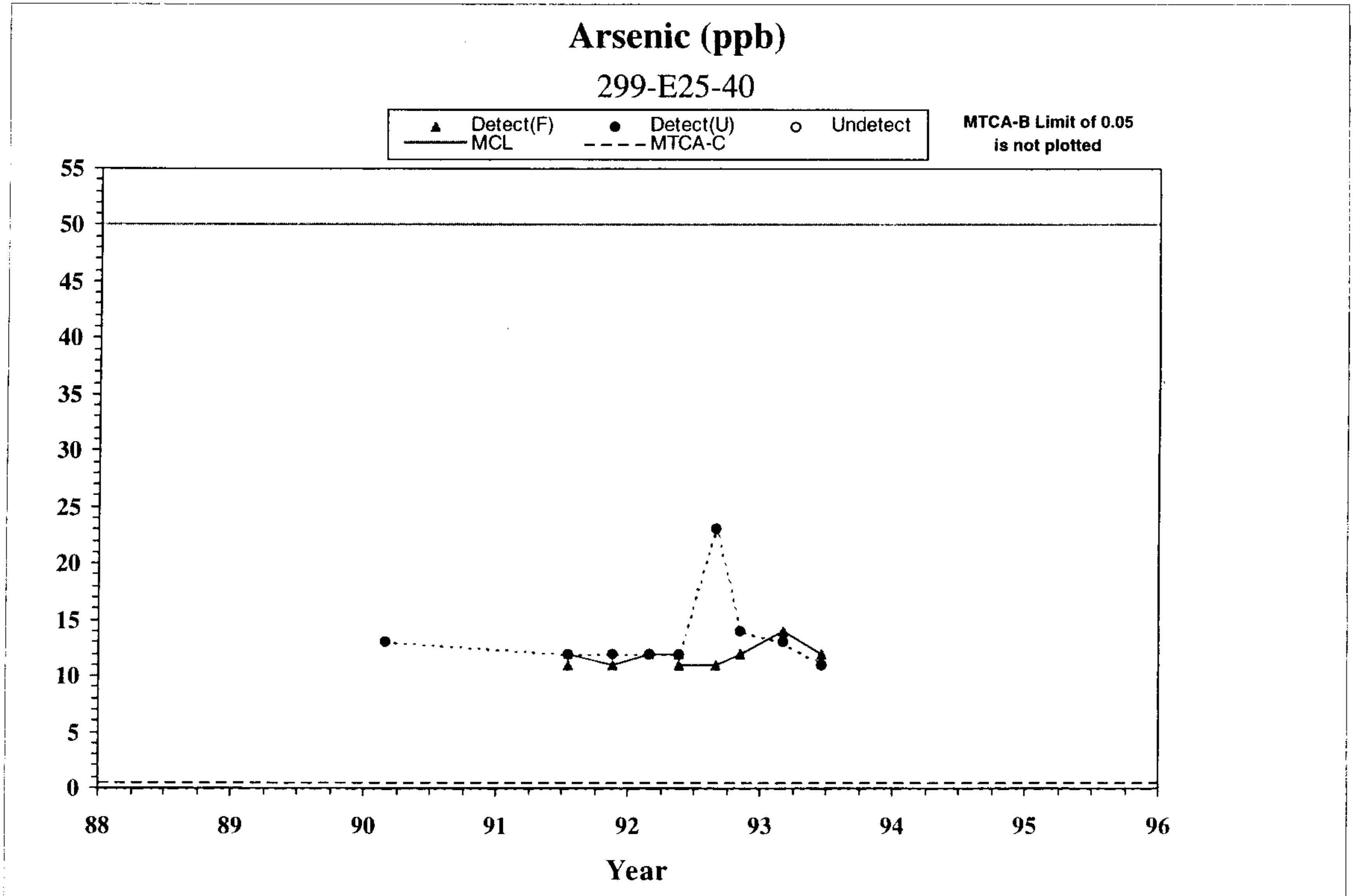


Figure 4-6. Arsenic Trend Analysis for Well 299-E25-40

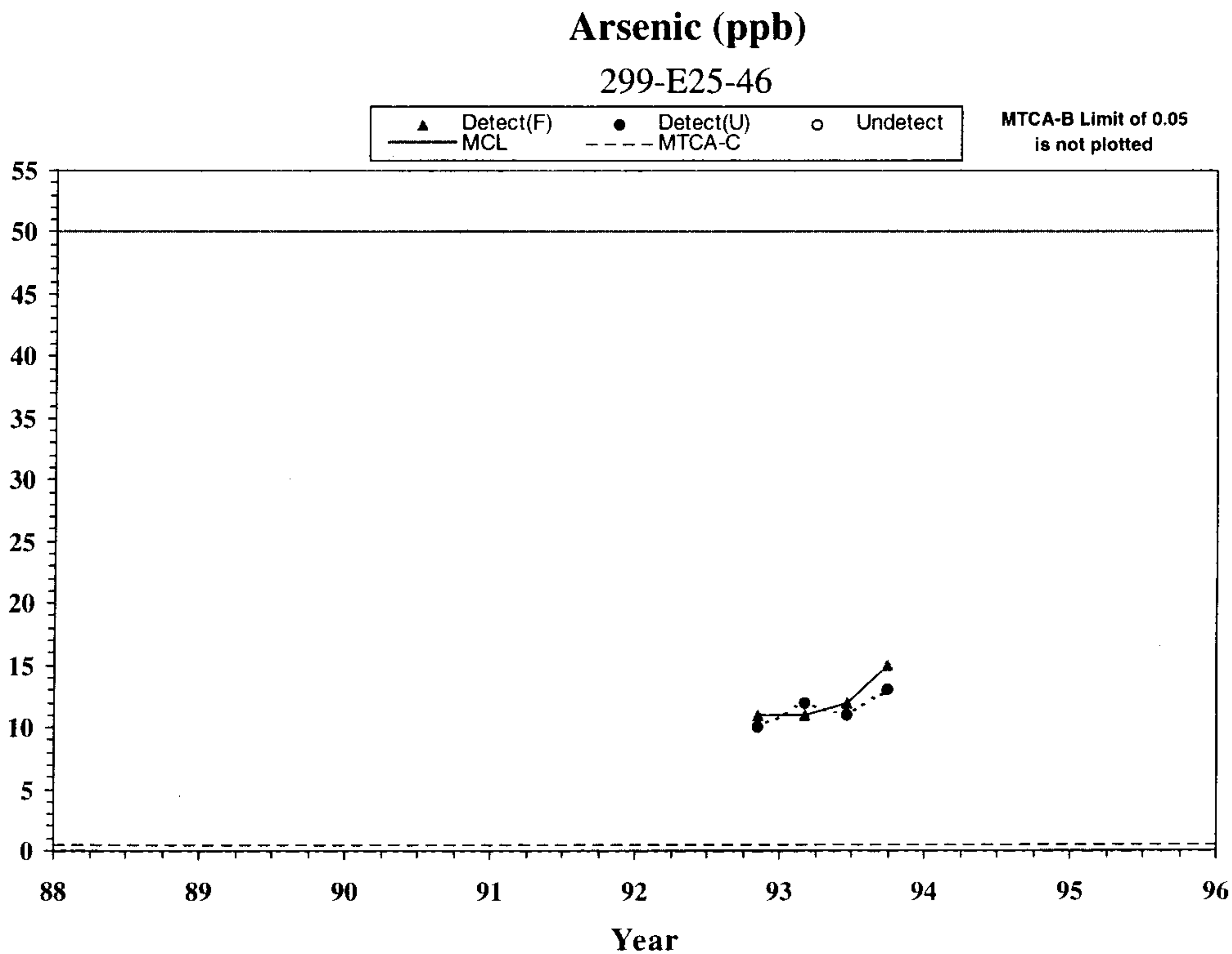


Figure 4-7. Arsenic Trend Analysis for Well 299-E25-46

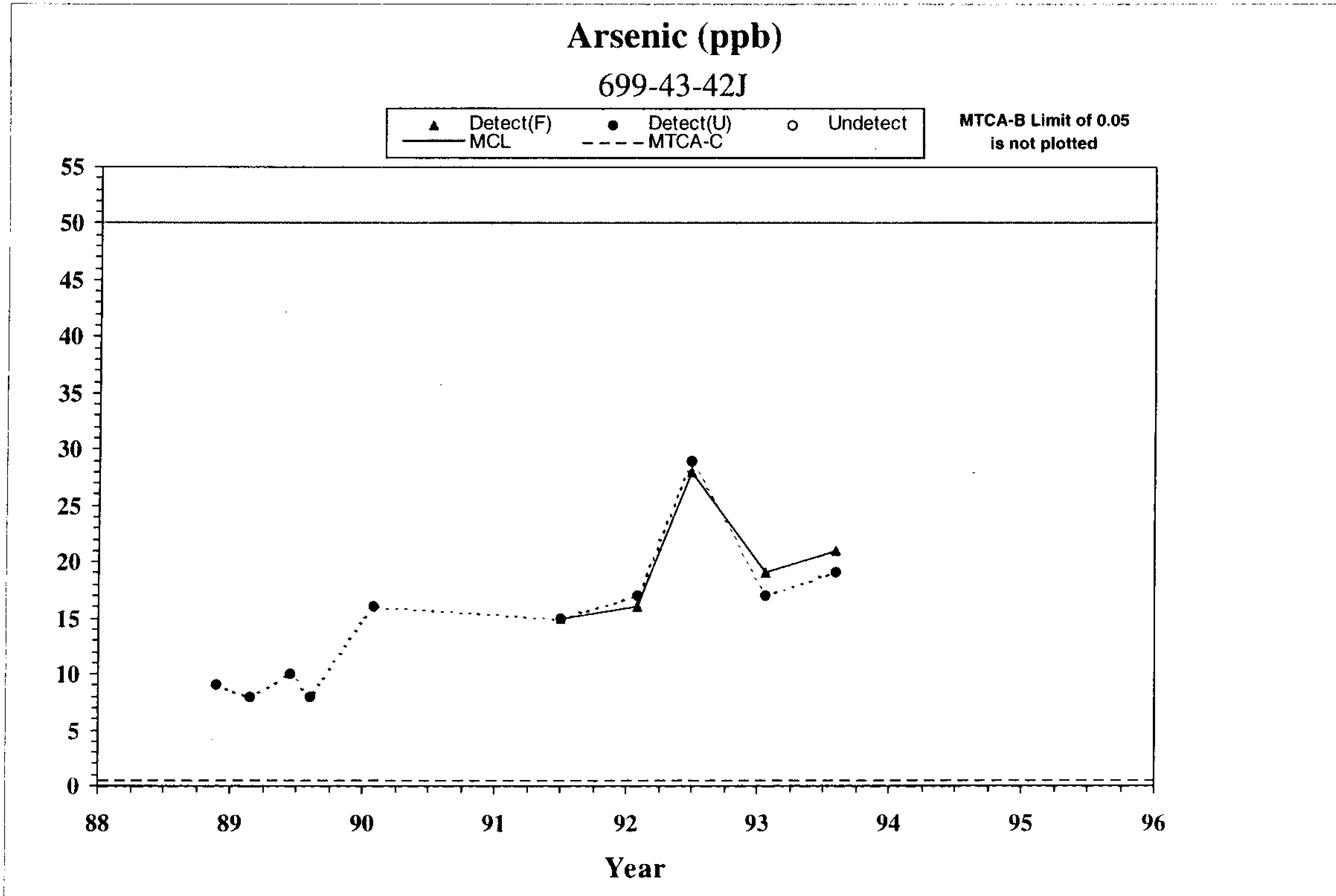
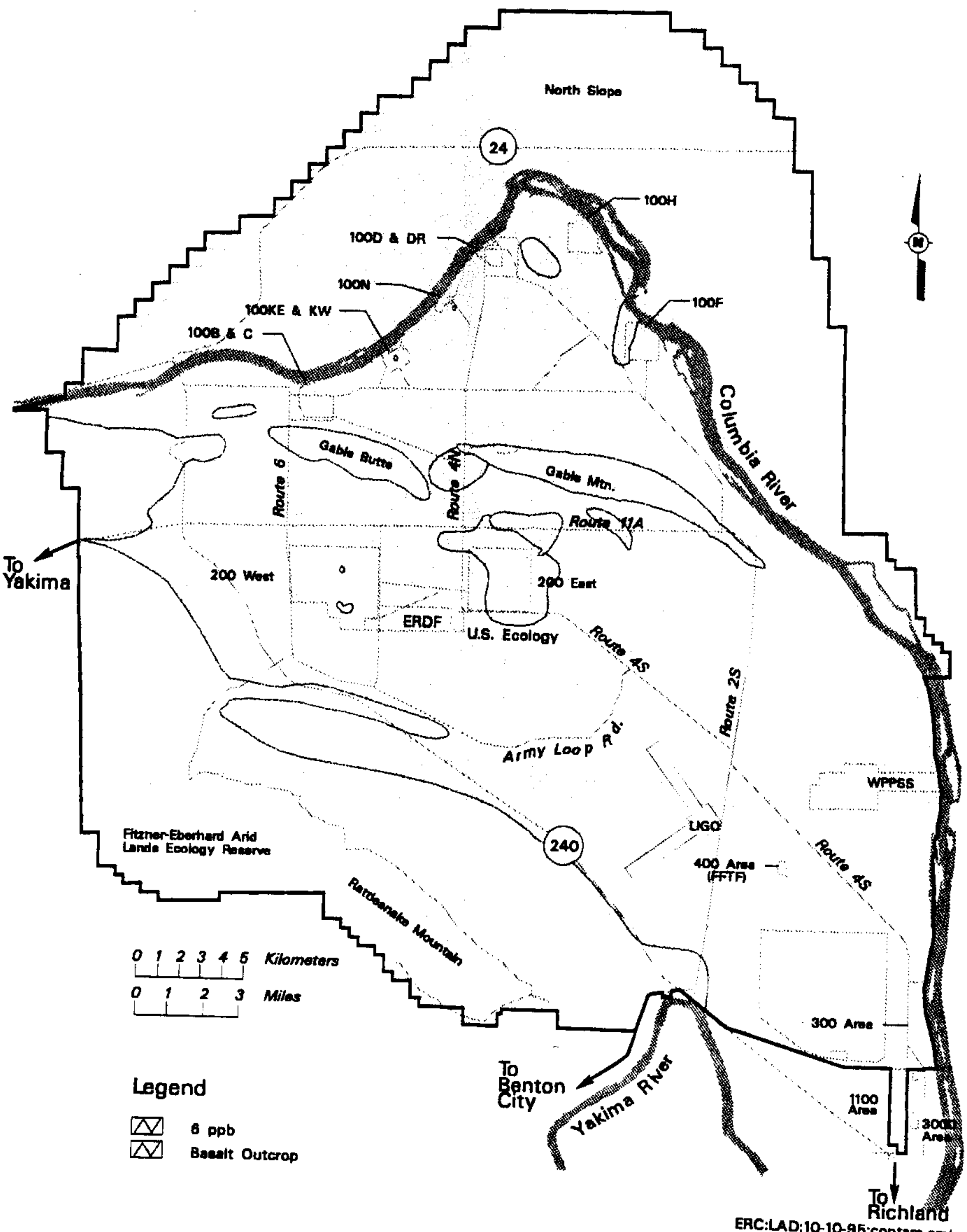


Figure 4-8. Arsenic Trend Analysis for Well 699-43-42J

Figure 4-9. Hanford Site Arsenic Contamination



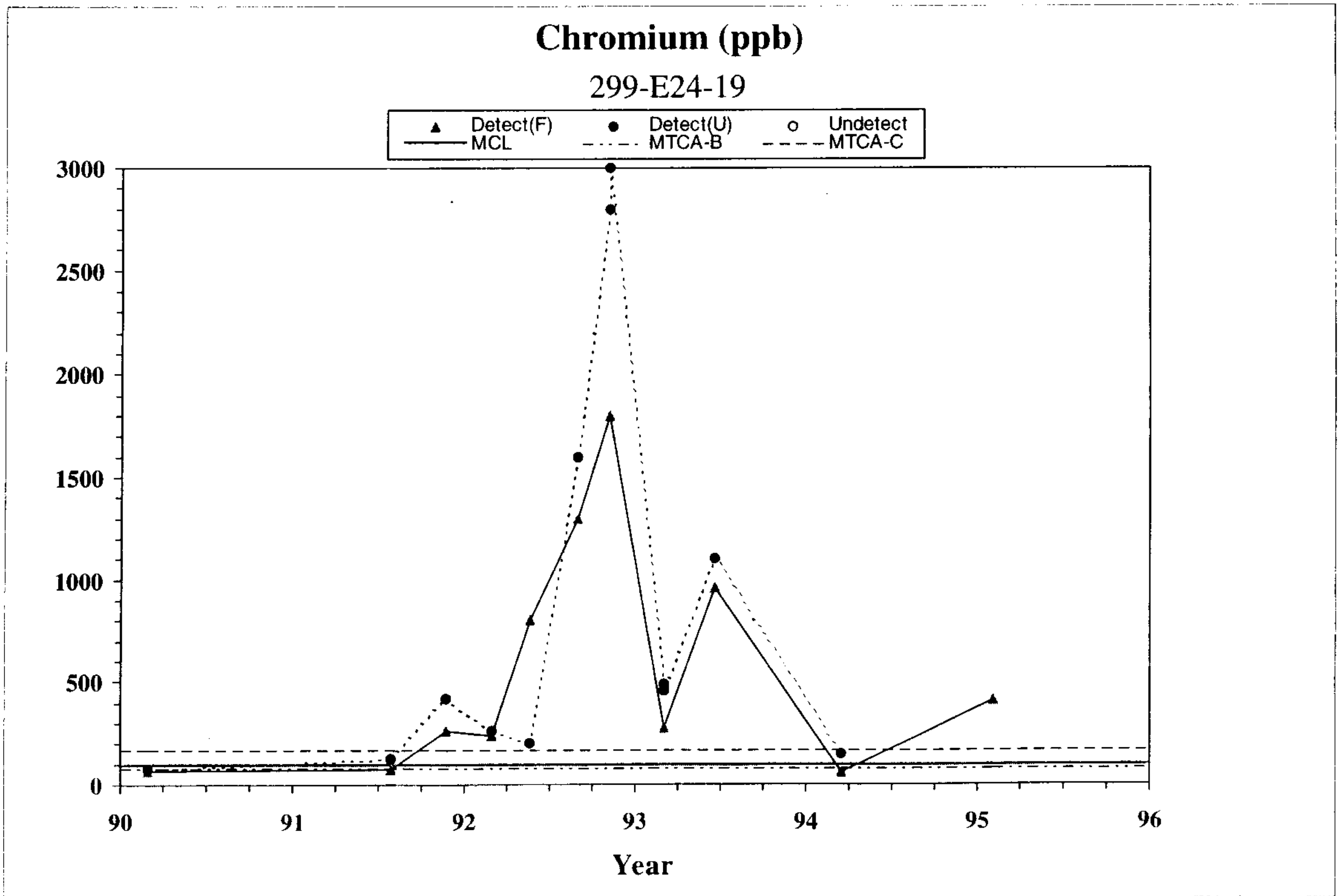


Figure 4-10. Chromium Trend Analysis for Well 299-E24-19

Figure 4-11. Hanford Site Chromium Contamination

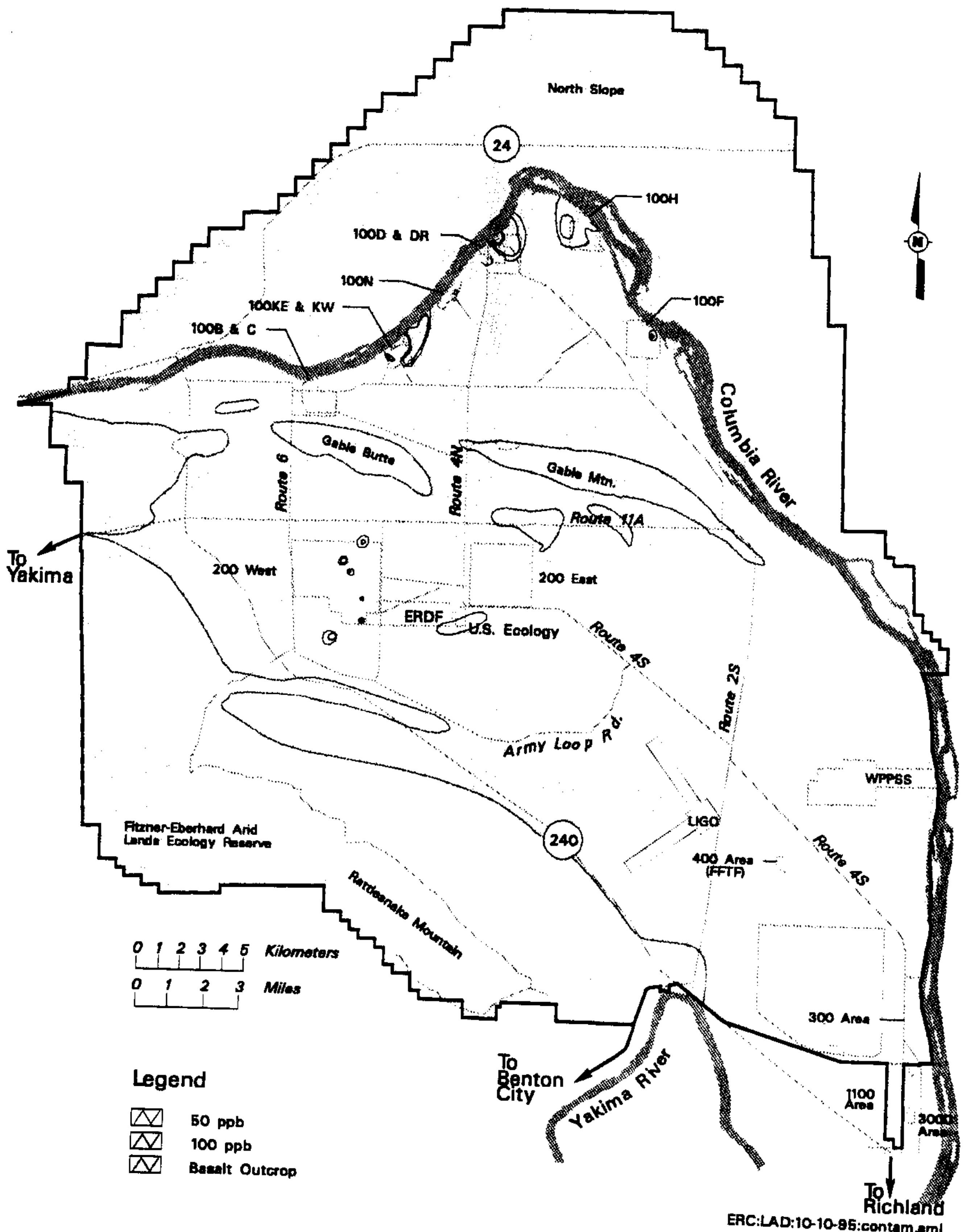
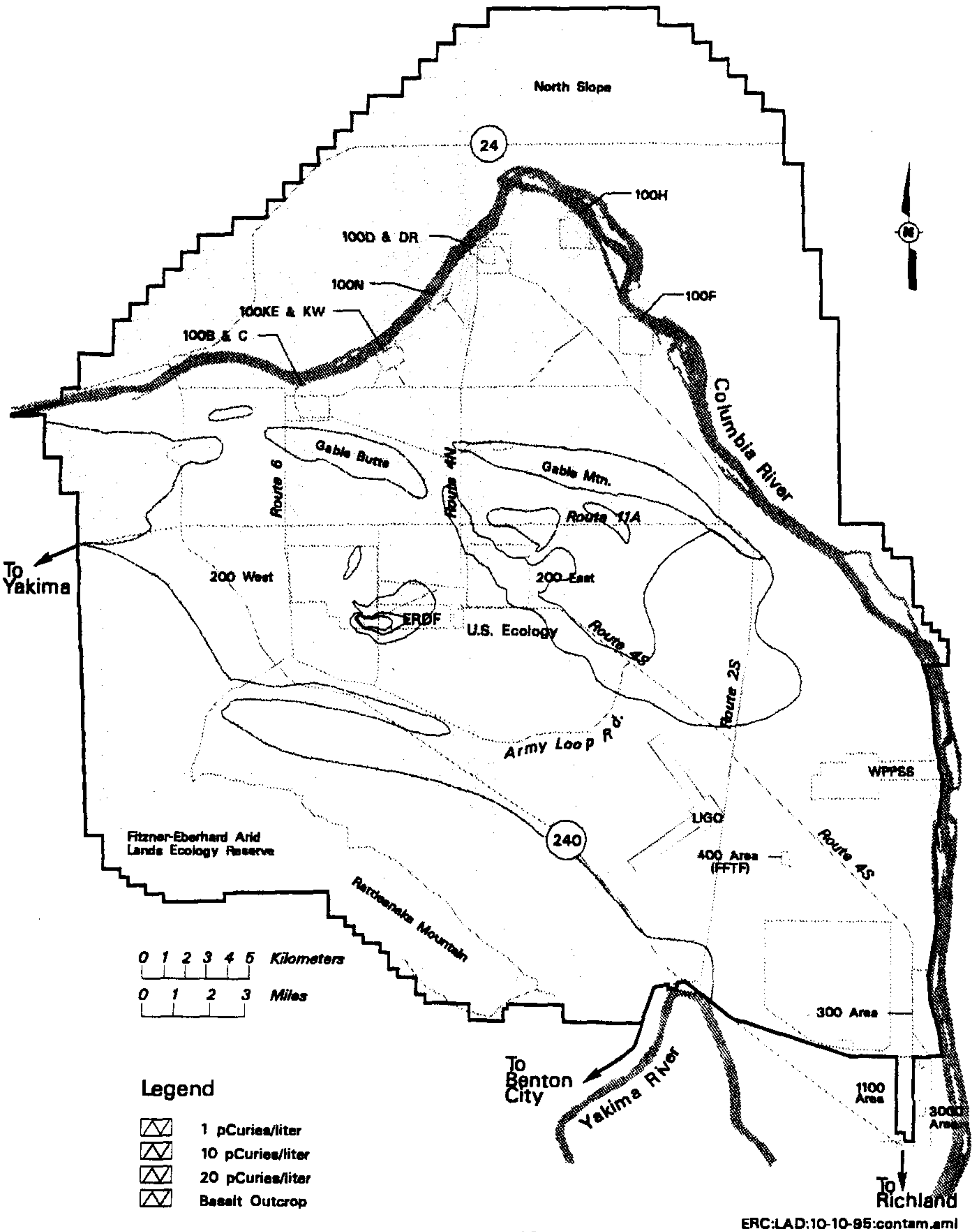


Figure 4-12. Hanford Site Iodine-129 Contamination



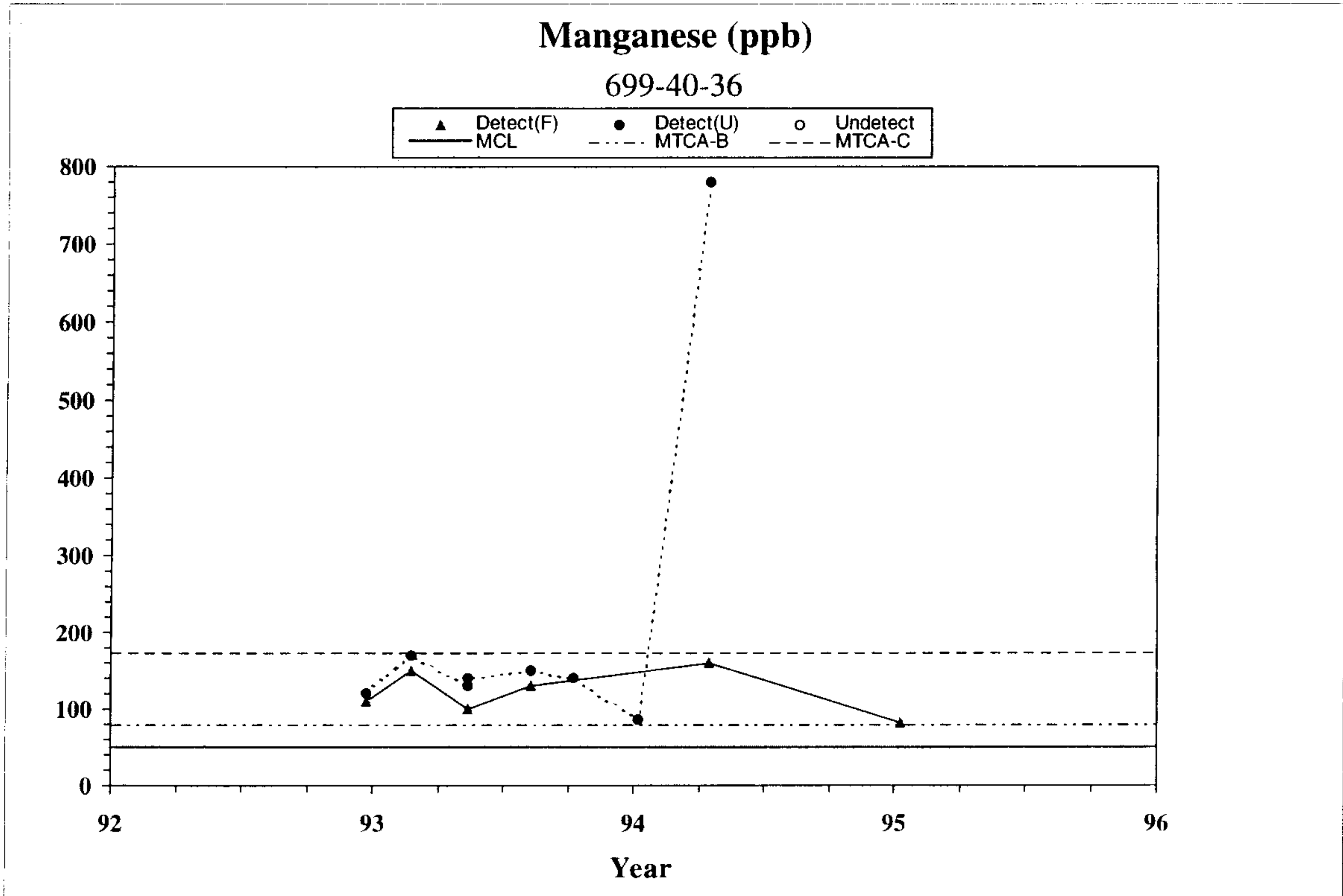


Figure 4-13. Manganese Trend Analysis for Well 699-40-36

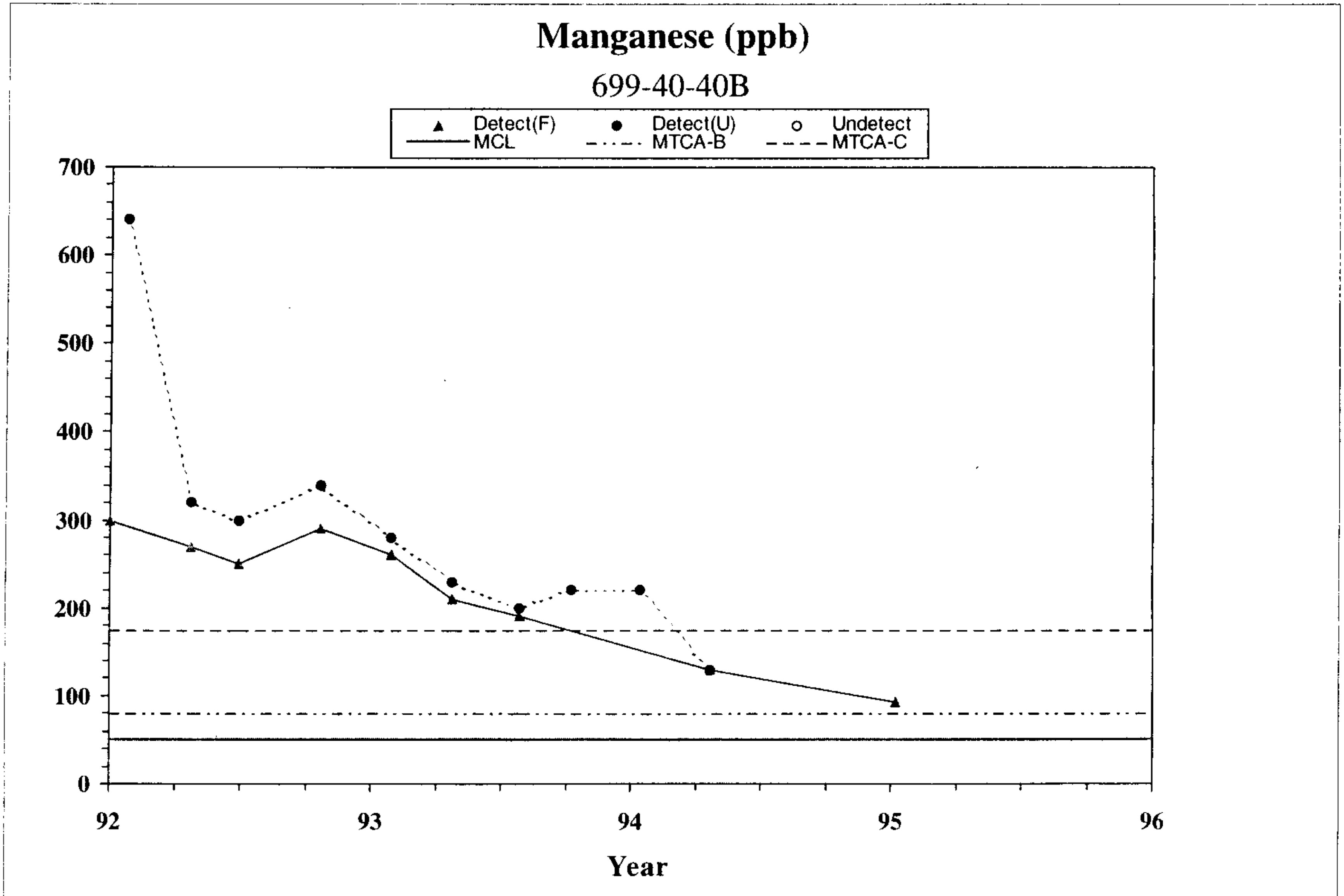


Figure 4-14. Manganese Trend Analysis for Well 699-40-40B

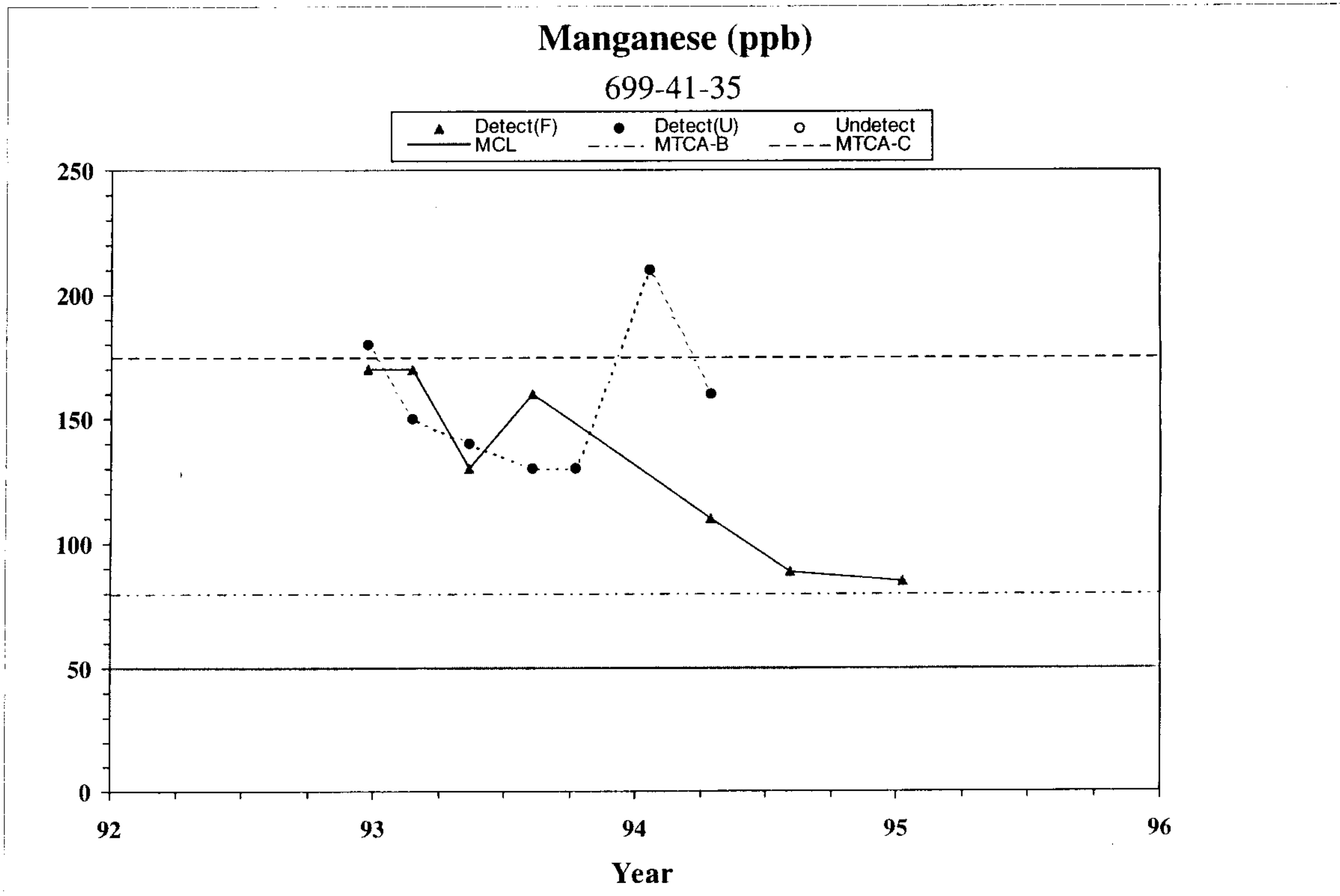


Figure 4-15. Manganese Trend Analysis for Well 699-41-35

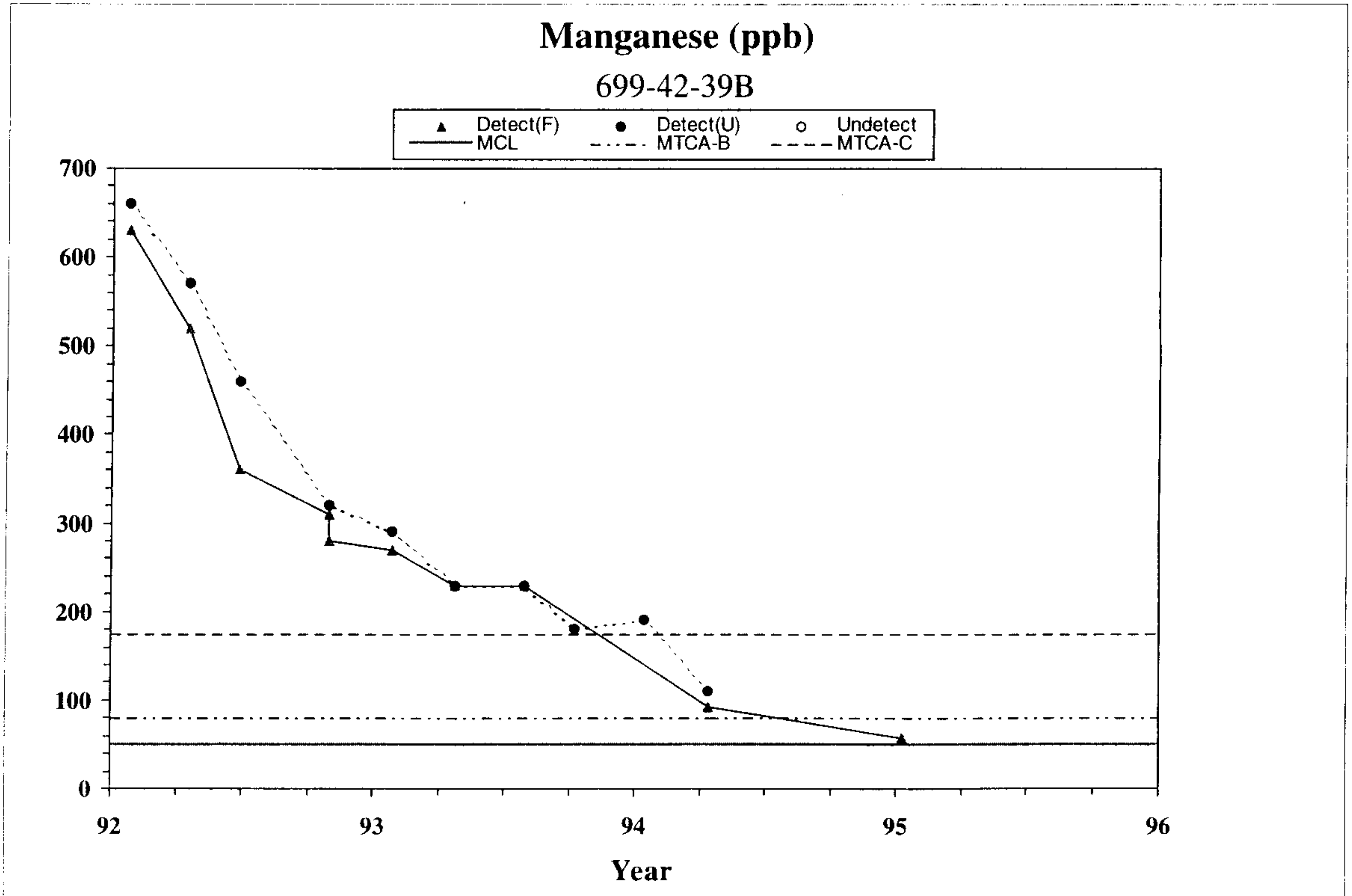


Figure 4-16. Manganese Trend Analysis for Well 699-42-39B

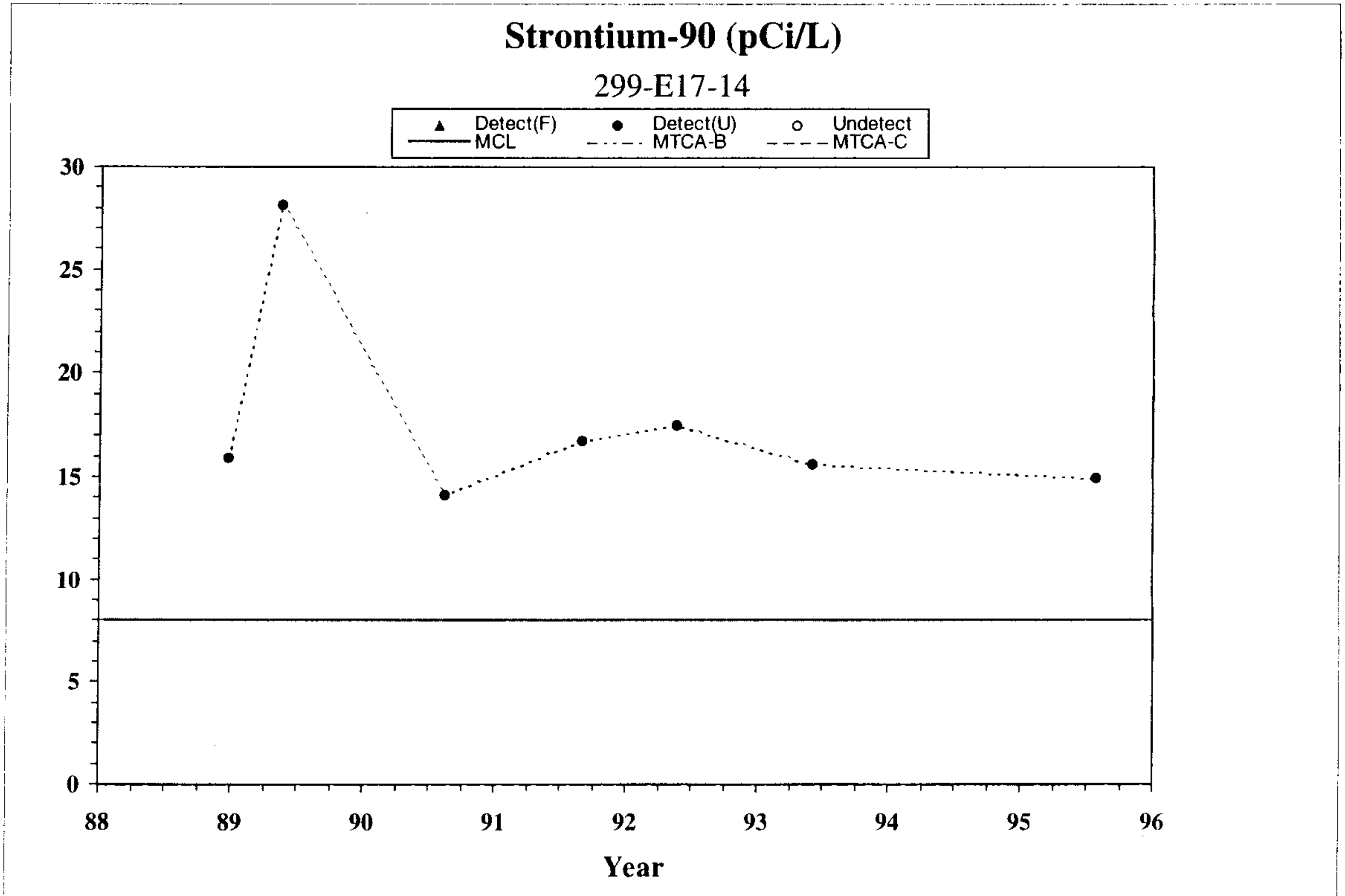


Figure 4-17. Strontium-90 Trend Analysis for Well 299-E17-14

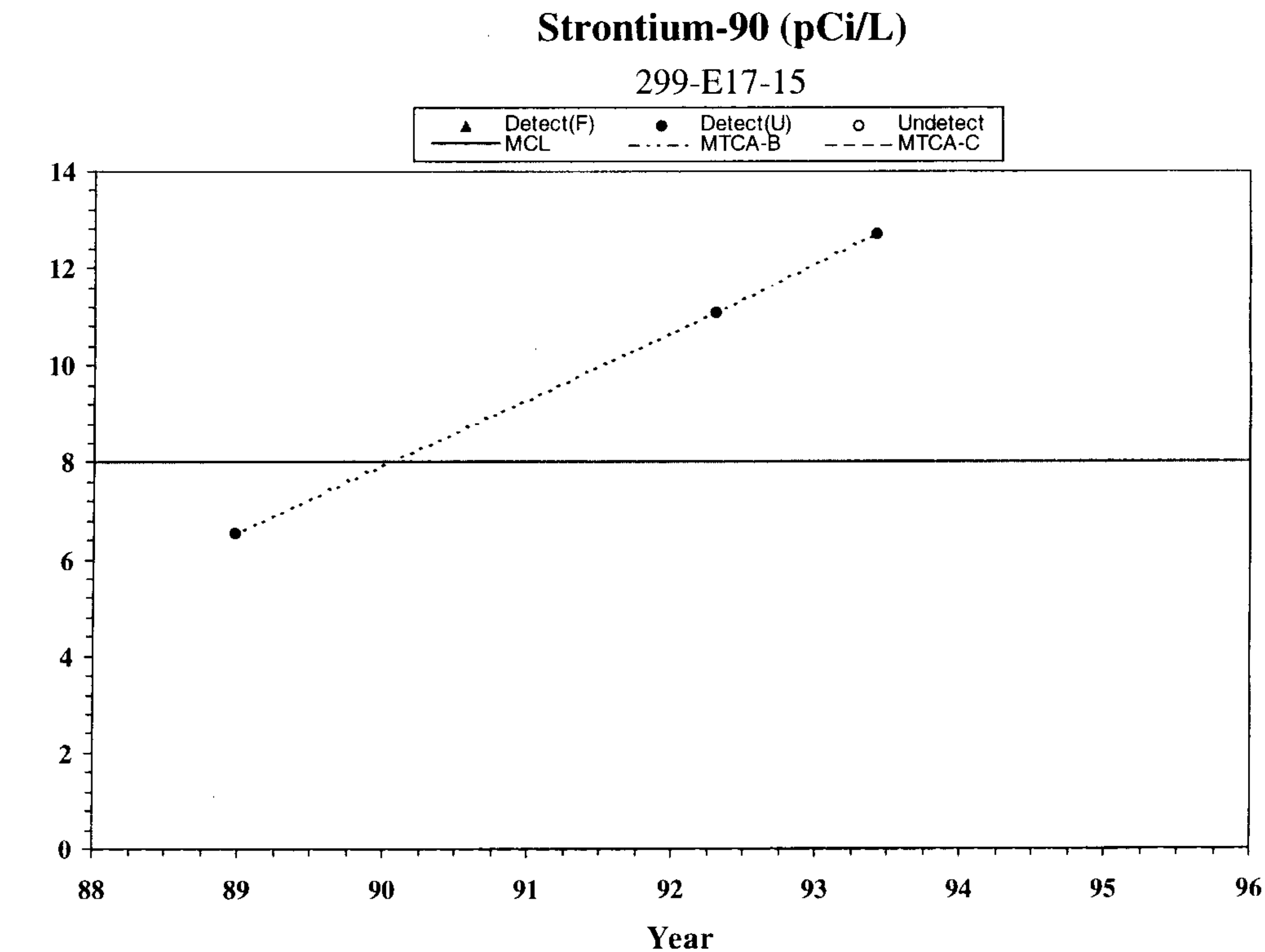


Figure 4-18. Strontium-90 Trend Analysis for Well 299-E17-15

Figure 4-19. Hanford Site Strontium-90 Contamination

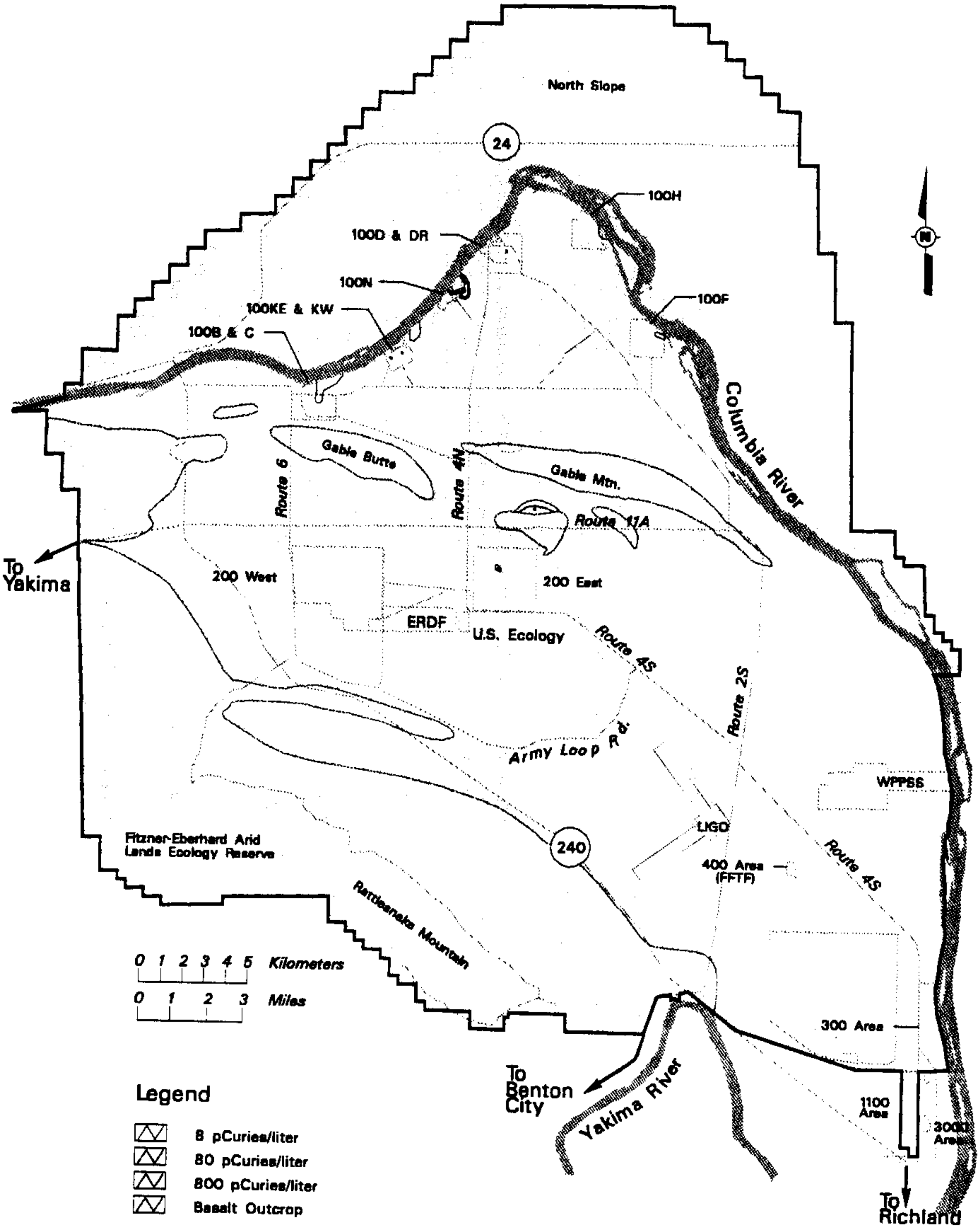


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Figure 4-20. Hanford Site Tritium Contamination

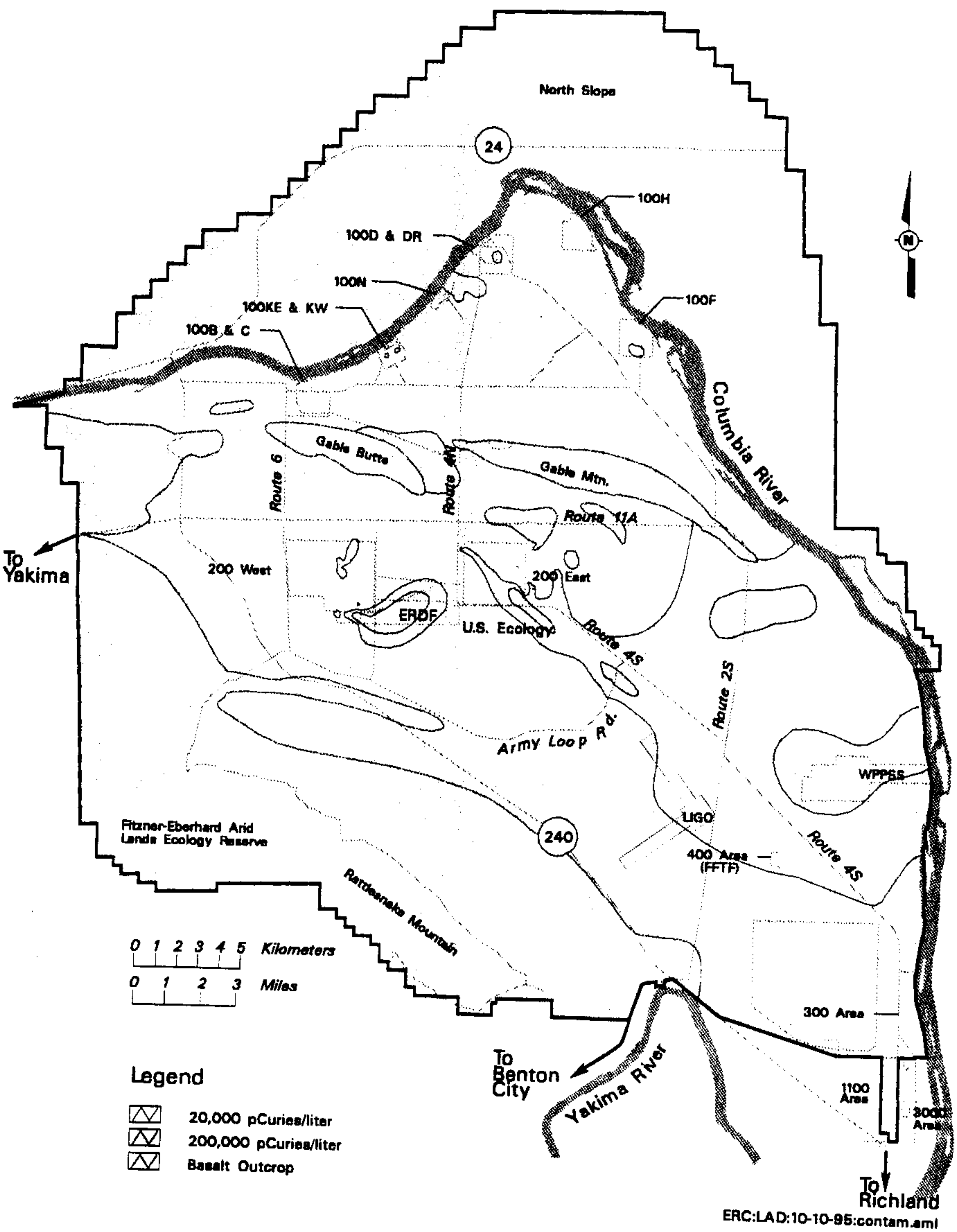
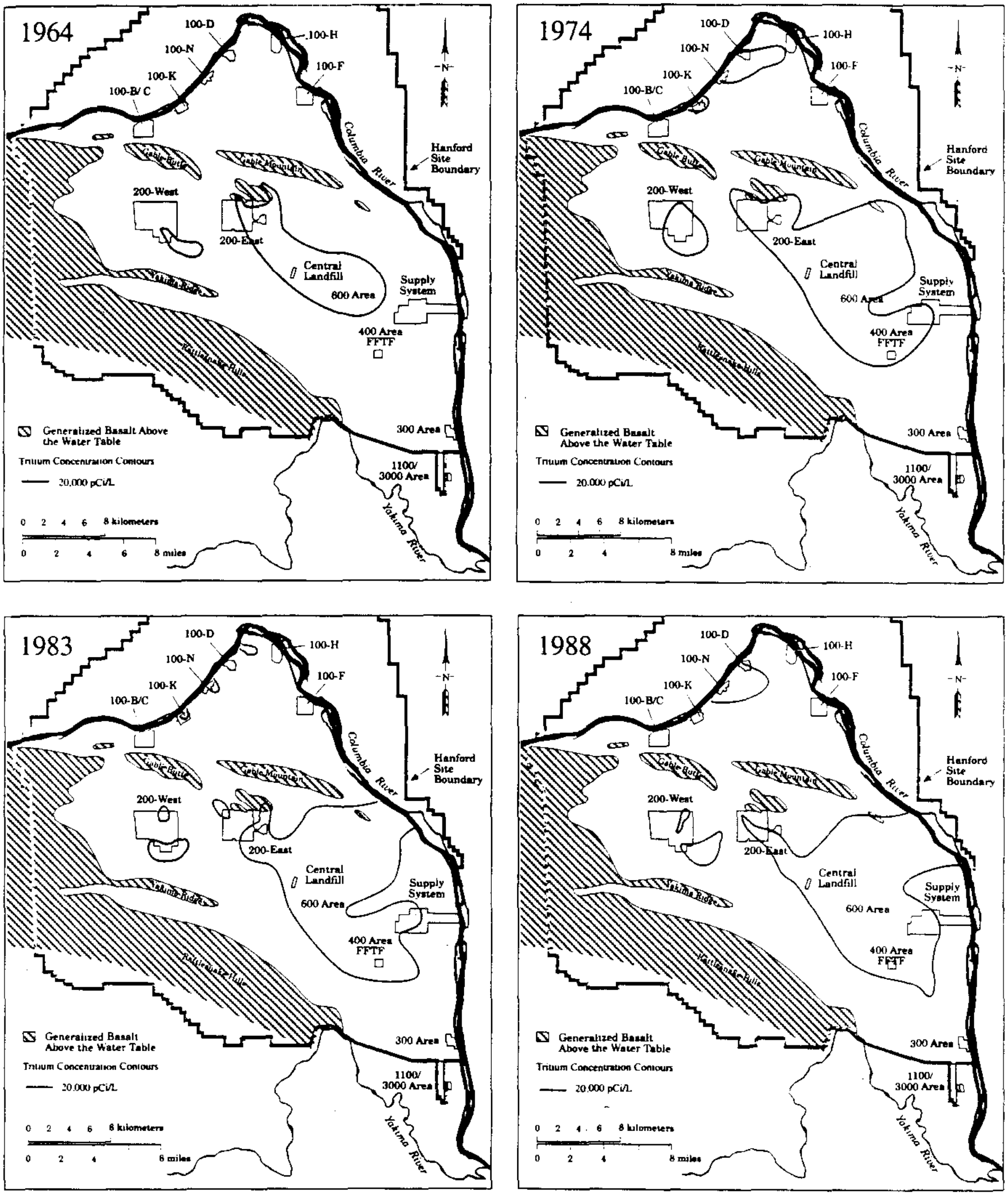


Figure 4-21. Historical Tritium Plumes



S9402063.76

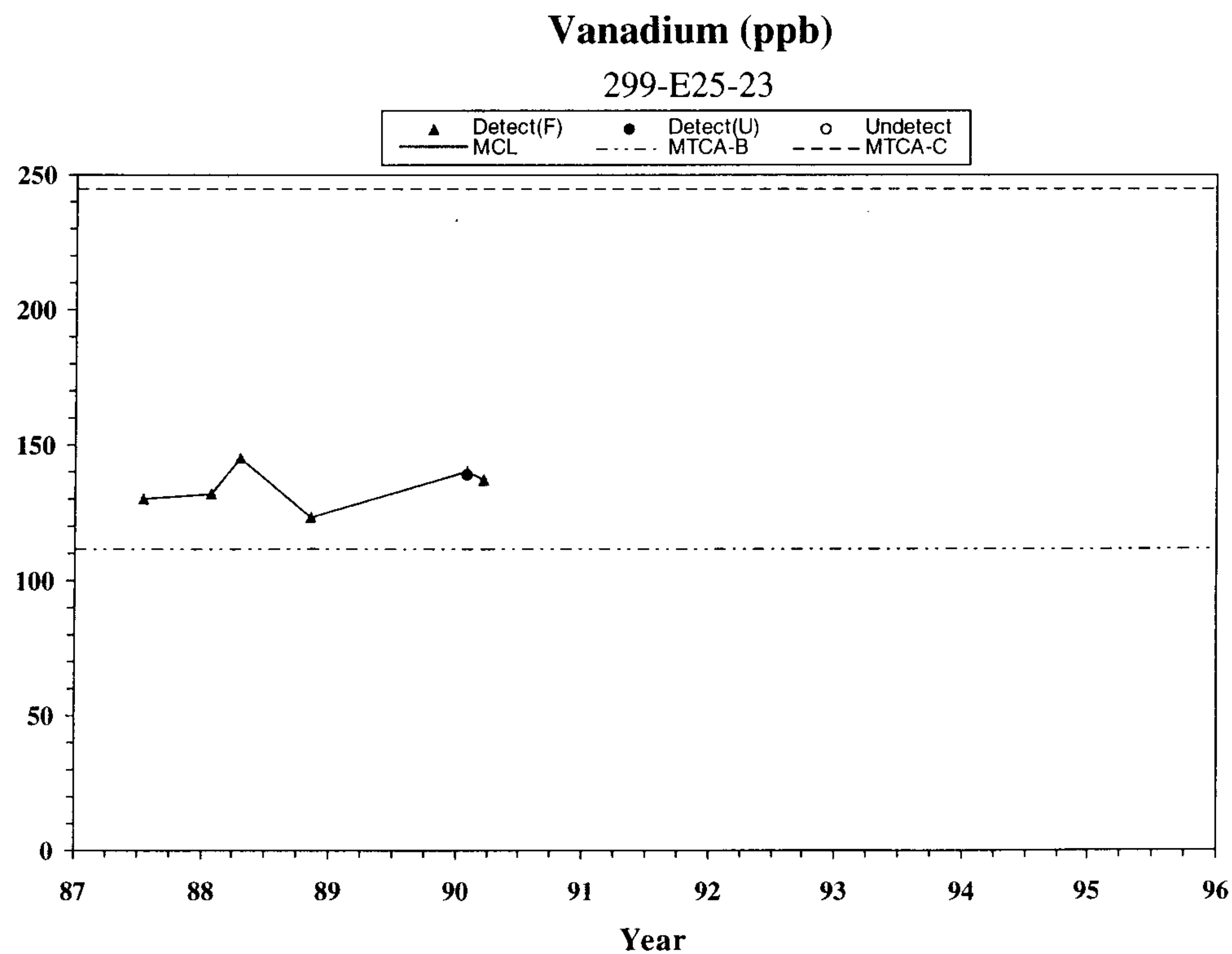


Figure 4-22. Vanadium Trend Analysis for Well 299-E25-23

Figure 4-23. Hanford Site Nitrate Contamination

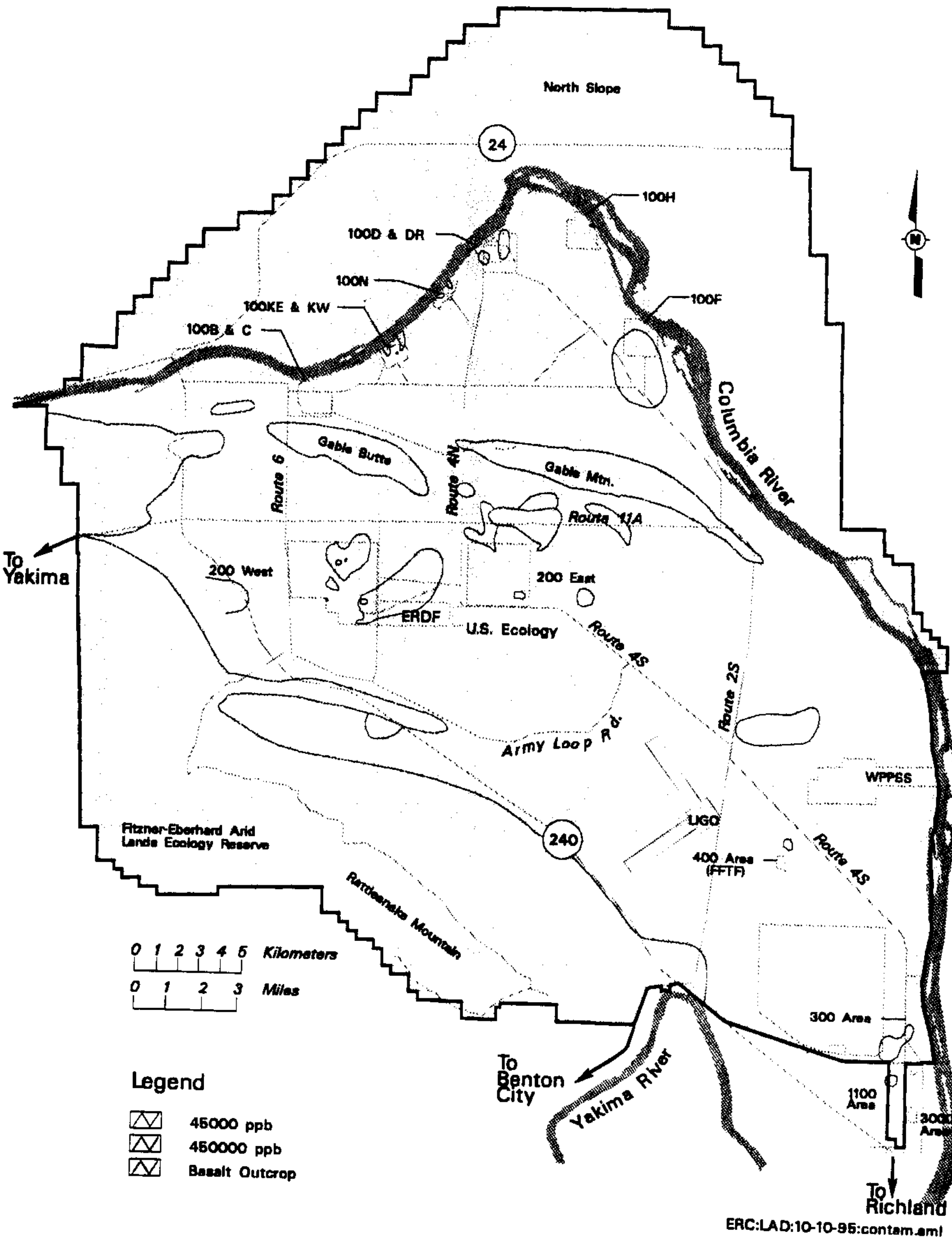
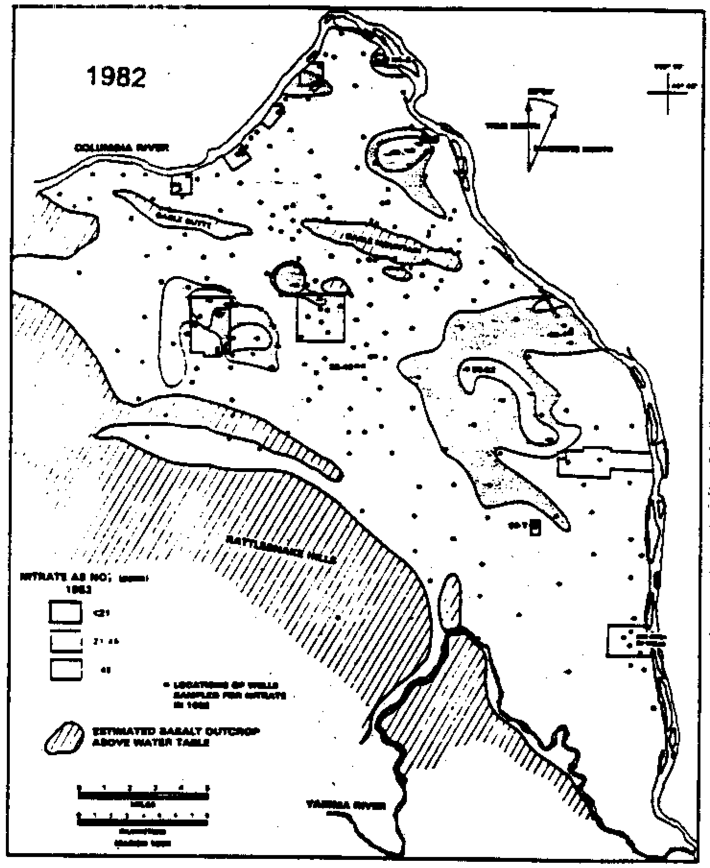


Figure 4-24. Historical Nitrate Plumes



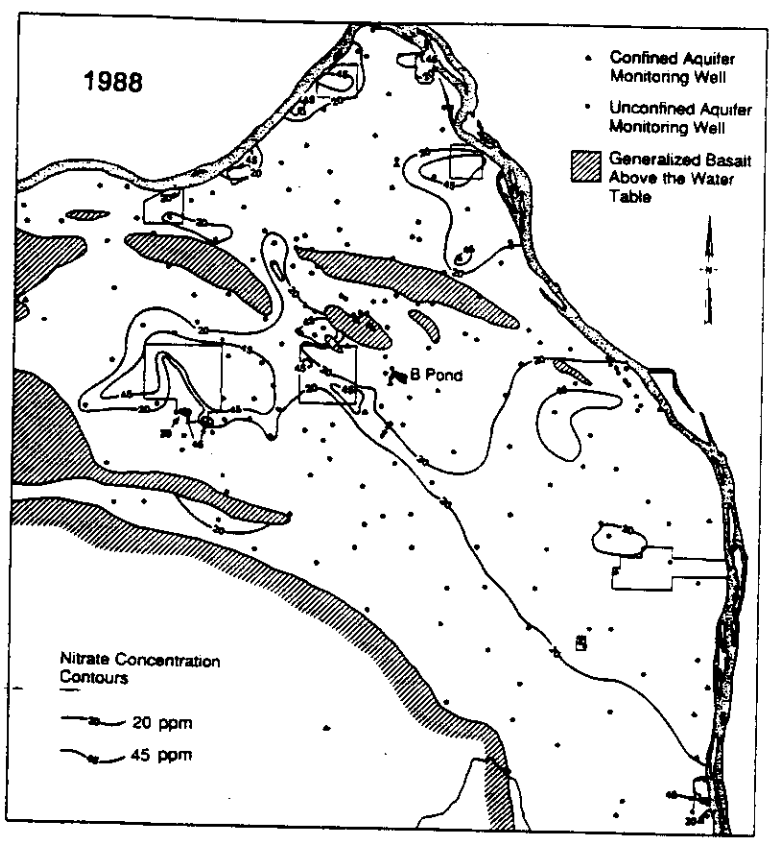


Figure 4-25. Hanford River Miles on the Columbia River

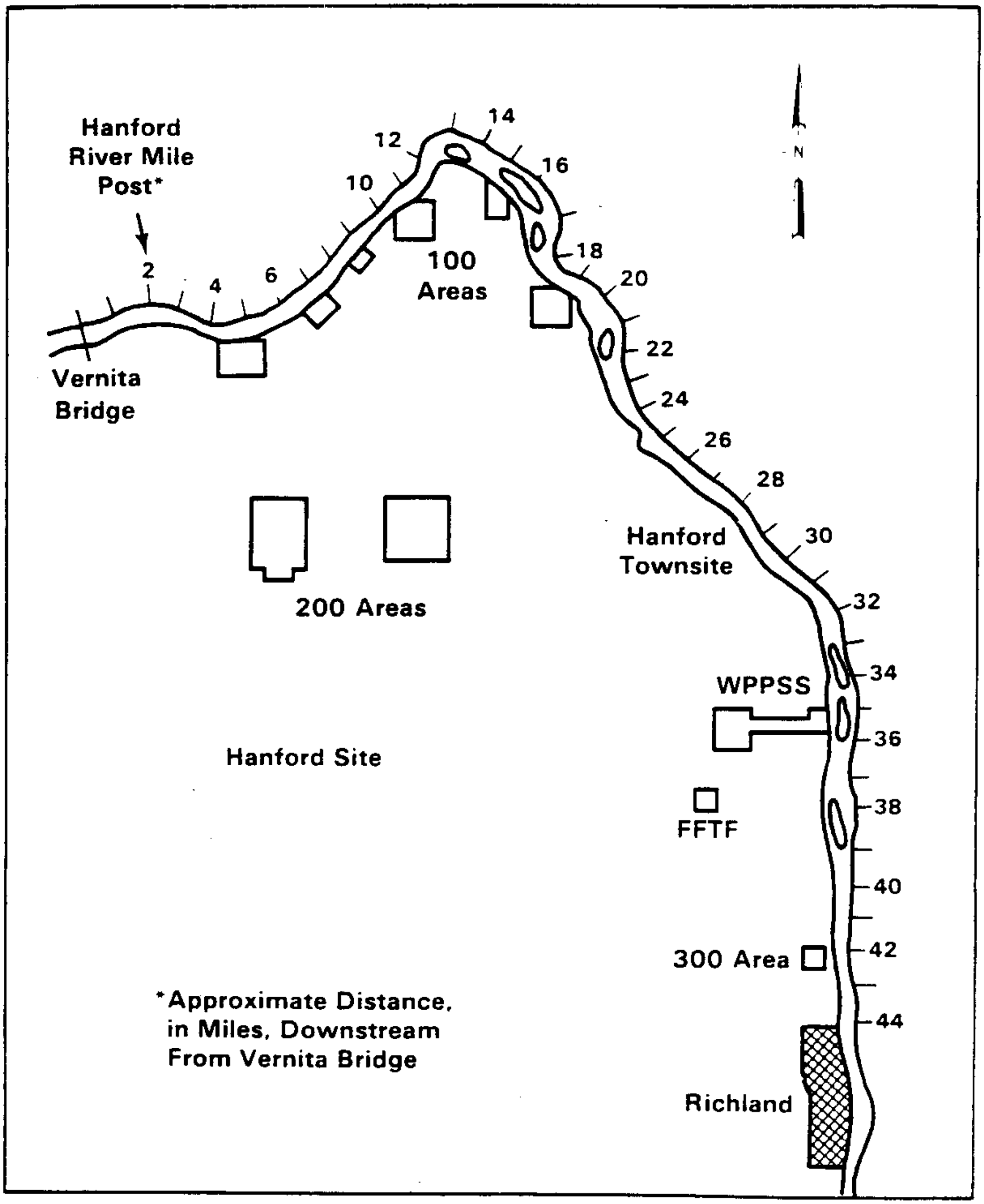


Table 4-1. Source Waste Sites Above 200-PO-1

Waste Site	
CRIBS	**OU**
216-A-1	PO-5
216-A-2	PO-2
216-A-3	PO-2
216-A-4	PO-2
216-A-5	PO-2
216-A-6	PO-4
216-A-7	PO-5
216-A-8	PO-5
216-A-9	PO-2
216-A-10	PO-2
216-A-21	PO-2
216-A-24	PO-5
216-A-27	PO-2
216-A-30	PO-2
216-A-31	PO-2
216-A-32	PO-2
216-A-36-A	PO-2
216-A-36-B	PO-2
216-A-37-1	PO-4
216-A-37-2	PO-4
216-A-38	PO-2
216-A-39	PO-3
216-A-41	PO-2
216-A-45	PO-2
216-B-14	BP-2
216-B-15	BP-2
216-B-16	BP-2
216-B-17	BP-2
216-B-18	BP-2
216-B-19	BP-2
TRENCHES	
216-A-18	PO-5
216-A-19	PO-5
216-A-20	PO-5
216-A-40	PO-2
216-B-20	BP-2
216-B-21	BP-2
216-B-22	BP-2
216-B-23	BP-2
216-B-24	BP-2
216-B-25	BP-2
216-B-26	BP-2
216-B-27	BP-2
216-B-28	BP-2
216-B-29	BP-2
216-B-30	BP-2
216-B-31	BP-2
216-B-32	BP-2
216-B-33	BP-2
216-B-34	BP-2
216-B-52	BP-2
216-B-53-A	BP-2
216-B-53-B	BP-2
216-B-54	BP-2
216-B-58	BP-2

Waste Site	
FRENCH DRAINS	**OU**
216-A-11	PO-2
216-A-12	PO-2
216-A-13	PO-2
216-A-14	PO-2
216-A-15	PO-2
216-A-16	PO-5
216-A-17	PO-5
216-A-23A	PO-5
216-A-23B	PO-5
216-A-22	PO-2
216-A-26	PO-2
216-A-26-A	PO-2
216-A-28	PO-2
216-A-33	PO-2
216-A-35	PO-2
PONDS	
216-B-3	BP-11
216-B-3A,B,C	BP-11
2101-M Pond	SS-1
DITCHES	
216-A-29	PO-5
216-A-34	PO-5
TANK FARMS, etc	
241-A (6)	PO-3
241-AP (7)	PO-3
241-AW (6)	PO-3
241-AX (4)	PO-3
241-AY (2)	PO-3
241-AZ (2)	PO-3
Diversion Boxes	

Table 4-2. Source Waste Sites Potentially Impacting Groundwater

CRIBS

216-A-3	216-A-4	216-A-5	216-A-6	216-A-7
216-A-8	216-A-9	216-A-10	216-A-21	216-A-24
216-A-27	216-A-30	216-A-36A	216-A-36B	216-A-37-1
216-A-37-2	216-A-45	216-B-14	216-B-15	216-B-16
216-B-17	216-B-18	216-B-19		

FRENCH DRAINS

216-A-11	216-A-12	216-A-13	216-A-15	216-A-16
216-A-17				

TRENCHES

216-A-18	216-A-19	216-A-20	216-B-20	216-B-21
216-B-22	216-B-23	216-B-24	216-B-26	216-B-28
216-B-29	216-B-30	216-B-32	216-B-33	216-B-34
216-B-52	216-B-53A			

PONDS

216-B-3	216-B-3A	216-B-3B	216-B-3C

NOTES

The "A" designation in the waste site numbers represents a PUREX source site.

The "B" designation in the waste site numbers represents a B-Plant source site.

Shading represents a currently active site.

* Based on Tables 2-5 and 2-6 of DOE-RL 1992a

Table 4-3. Constituents Disposed at Sites Potentially Impacting Groundwater

RADIONUCLIDES		
Am-241	Pu-238	Sn-113
Co-60	Pu-239	Sr-90
Cs-137	Pu-240	U-238
H-3	Pu-241	Total U
I-129	Total Pu	Gross Alpha
Pm-147	Ru-106	Gross Beta
CHEMICAL CONSTITUENTS		
Ammonium Carbonate	Nitrate	Sodium Dichromate
Ammonium Nitrate	Nitric Acid	Sodium
Bismuth Phosphate	Normal Paraffin Hydrocarbons	Sulfate
Ferrocyanide	Phosphate	Tributyl Phosphate

Am = Americium
H = Hydrogen (Tritium)
Pu = Plutonium
Sr = Strontium
Co = Cobalt
I = Iodine
Ru = Ruthenium
U = Uranium
Cs = Cesium
Pm = Promethium
Sn = Tin

Table 4-4. Potential Levels of Concern for Groundwater Contaminants (page 1 of 2)

CONTAMINANTS OF POTENTIAL INTEREST IN THE 200-PO-1 OU
Units reported in micrograms/liter unless otherwise noted

CONSTITUENT	MCLs	Secondary MCLs	Proposed MCLs	MTCA B	MTCA C	RCRA [1]	Background
Aluminum	---	50 - 200	---	---	---	---	<200
Ammonium ion	---	---	---	---	---	---	120
Arsenic	50	---	---	0.05	0.50	50	10
Calcium 202		---	---	---	---	---	63,600
Cerium/ Praeseodymium 144	24 pCi/L	---	261 pCi/L		---	---	---
Cesium 137	145 pCi/L	---	119 pCi/L	---	---	---	---
Chloride	---	250,000	---	---	---	---	8,690/28,500
Chromium	100	---	---	16,000 (III) 80 (VI)	35,000 (III) 175 (VI)	50	---
Cobalt 60	121 pCi/L	---	218 pCi/L	---	---	---	---
Copper	---	1,000	---	592	1,300	---	<30
Fluoride	4,000	2,000	---	---	---	---	1,340/775
Gross alpha	15 pCi/L	---	15 pCi/L	---	---	---	63/5.79
Gross beta	4 mrem/yr	---	4 mrem/yr EDE	---	---	---	35.5/12.62
Iodine 129	0.48 pCi/L	---	21 pCi/L	---	---	---	---
Iron	---	300	---	---	---	---	86/291/818
Lead	15 [2]	---	---	---	---	50	<5
Magnesium	---	---	---	---	---	---	16,480
Manganese	---	50	---	80	175	---	24.5/163.5
Nickel	100	---	---	320	700	---	<30

Table 4-4. Potential Levels of Concern for Groundwater Contaminants (page 2 of 2)

CONTAMINANTS OF POTENTIAL INTEREST IN THE 200-PO-1 OU
Units reported in micrograms/liter unless otherwise noted

CONSTITUENT	MCLs	Secondary MCLs	Proposed MCLs	MTCA B	MTCA C	RCRA [1]	Background
Nitrate	10,000	---	---	25,600	56,000	---	12,400
Nitrite	1,000	---	---	1,600	3,500	---	---
Potassium	---	---	---	---	---	---	7,975
Radium	5 pCi/L	---	20 pCi/L	---	---	---	0.23
Ruthenium 106	24 pCi/L	---	203 pCi/L	---	---	---	---
Sodium	---	---	---	---	3.24	---	33,500
Strontium 90	8 pCi/L	---	42 pCi/L	---	---	---	---
Sulfate	---	250,000	---	---	---	---	90,500
Tritium	20,000 pCi/L	---	---	---	---	---	---
Uranium	125 pCi/L	---	29 pCi/L	48	105	---	3.43
Uranium 238	97 pCi/L	---	14.6 pCi/L	---	---	---	---
Vanadium	---	---	---	112	245	---	15
Zirconium/Niobium 95	145 pCi/L	---	1,460 pCi/L	---	---	---	---

MCLs for radionuclides calculated in accordance with 40 CFR 141.16(b), based on "Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure".

[1] Groundwater protection standards for TSD facilities found in 40 CFR 264.94 and WAC 173-303-645(5).

[2] Represents the action level as specified in the Safe Drinking Water Act, Subpart I, Control of Lead and Copper.

Table 4-5. Contaminant Screening Results (page 1 of 3)

Constituent	Retain	Eliminate	Reason
1,1,2,2-Tetrachloroethane		•	Two detections above MTCA-B value of 0.219ppb. However each detection was a single detection in a well
1,2-Dichloroethane		•	2 detections above MTCA-B value of 0.481 ppb; Reasons for removing from potential contaminant list - single detection in well.
2,4-Dinitrophenol		•	2 detections above MTCA-B value of 32 ppb; Reasons for removing from potential contaminant list - single detection in well.
4,4'-DDT		•	5 detections above MTCA-B value of 0.257 ppb; Reasons for removing from potential contaminant list - single detection in well, only sampling event with detection in well.
Aldrin		•	5 detections above MTCA-B value of 0.00515 ppb; Reasons for removing from potential contaminant list - single detection in well, only sampling event with detection in well.
Alpha-BHC		•	1 detection above MTCA-B value of 0.0139 ppb; Reasons for removing from potential contaminant list - single detection in well.
Antimony		•	18 detections above MTCA-B value of 6.4 ppb; Reasons for removing from potential contaminant list - single detection in well, only sampling event with detection in well.
Bromodichloromethane		•	1 detection above MTCA-B value of 0.706 ppb; Reasons for removing from potential contaminant list - single detection in well.
Barium		•	2 detections above MTCA-B value of 1120 ppb; Reasons for removing from potential contaminant list - value not consistent with trend in well, value from old sample, recent samples show no problem.
Benzene		•	2 detections above MTCA-B value of 1.5 ppb; Reasons for removing from potential contaminant list - single detection in well.
Bis(2-ethylhexyl) phthalate		•	13 detections above MTCA-B value of 6.25 ppb; Reasons for removing from potential contaminant list - single detection in well, laboratory contamination problems, value not consistent with trend in well.
Cadmium		•	12 detections above MTCA-B value of 8 ppb; Reasons for removing from potential contaminant list - single detection in well, only sampling event with detection in well, value from old sample, recent samples show no problem.
Cerium/ Praseodymium-144		•	6 detections above MCL value of 24 pCi/L; Reasons for removing from potential contaminant list - value from old sample, recent samples show no problem, value not consistent with trend in well.
Chloroform		•	2 detections above MTCA-B value of 7.17 ppb; Reasons for removing from potential contaminant list - single detection in well, value from old sample, recent samples show no problem.
Copper		•	2 detections above MTCA-B value of 592 ppb; Reasons for removing from potential contaminant list - value not consistent with trend in well.
Dibromochloromethane		•	1 detection above MTCA-B value of 0.521 ppb; Reasons for removing from potential contaminant list - single detection in well.
Dieldrin		•	5 detections above MTCA-B value of 0.00547 ppb; Reasons for removing from potential contaminant list - single detection in well, only sampling event with detection in well.
Dimethoate		•	4 detections above MTCA-B value of 3.2 ppb; Reasons for removing from potential contaminant list - single detection in well, value from old sample, recent samples show no problem.
Endrin		•	5 detections above MCL value of 2 ppb; Reasons for removing from potential contaminant list - single detection in well, only sampling event with detection in well.

Table 4-5. Contaminant Screening Results (page 2 of 3)

Constituent	Retain	Eliminate	Reason
Gamma-BHC (Lindane)		•	6 detections above MTCA-B value of 0.0673 ppb; Reasons for removing from potential contaminant list - single detection in well, only sampling event with detection in well.
Gross alpha		•	27 detections above MCL value of 15 pCi/L; Reasons for removing from potential contaminant list - value from old sample, recent samples show no problem.
Heptachlor		•	8 detections above MTCA-B value of 0.0194 ppb; Reasons for removing from potential contaminant list - single detection in well, only sampling event with detection in well.
Lead		•	5 detections above MCL value of 50 ppb; Reasons for removing from potential contaminant list - value from old sample, recent sampling shows no problem, single detection in well.
Mercury		•	1 detection above MTCA-B value of 4.8 ppb; Reasons for removing from potential contaminant list - single detection in well.
Methylenechloride		•	24 detections above MTCA-B value of 5.83 ppb; Reasons for removing from potential contaminant list - single detection in well, value not consistent with trend in well, only sampling event with detection in well.
Nickel		•	15 detections above MTCA-B value of 320 ppb; Reasons for removing from potential contaminant list - value from old sample, recent sampling shows no [illegible]lem, single detection in well.
Pentachlorophenol		•	7 detections above MTCA-B value of 0.729 ppb; Reasons for removing from potential contaminant list - single detection in well, value from old sample, recent sampling shows no problem.
Polychlorodibenzodioxin		•	1 detection above MTCA-B value of 0.0114 ppb; Reasons for removing from potential contaminant list - single detection in well.
Styrene		•	4 detections above MTCA-B value of 1.46 ppb; Reasons for removing from potential contaminant list - value from old sample, recent sampling shows no problem.
Technetium-99		•	1 detection above MCL value of 727 ppb; Reasons for removing from potential contaminant list - single detection in well.
Tetrachloroethene		•	212 detections above MTCA-B values of 0.858 ppb; Reasons for removing from potential contaminant list - value from old sample, recent sampling shows no problem.
Trichloroethene		•	39 detections above MTCA-B value of 3.98 ppb; Reasons for removing from potential contaminant list - single detection in well, value from old sample, recent sampling shows no problem.
Uranium		•	8 detections above MCL value of 20 pCi/L; Reasons for removing from potential contaminant list - value not consistent with trend in well, value from old sample, recent sampling shows no problem.
Zirconium/Niobium-95		•	3 detections above MCL value of 145 pCi/L; Reasons for removing from potential contaminant list - single detection in well, value not consistent with trend in well.
Hydrazine		•	27 detections above MTCA-B value of 0.0292 ppb; Reasons for removing detections from consideration - single detection in well. Remainder of detections from the same rounds reported as detections only after lab changed its reporting methods. What used to be reported as a undetect is now reported as a value with a "L" qualifier indicating the detection was below the contract required detection limit but detectable by their instruments....only a problem if treat "L" qualified data as a detection.
Ruthenium-106			334 detections above MCL val[illegible]/L; Reasons for [illegible] detections from [illegible]deration [illegible] from old sample, recent sampling shows no problem, single detection in well. Remainder of detections from sampling one year old or older if decay to present concentration is not a problem.

Table 4-5. Contaminant Screening Results (page 3 of 3)

Constituent	Retain	Eliminate	Reason
Beryllium		•	122 detections above MTCA-B value of 0.0203 ppb; Reasons for removing detections from consideration - single detection in well, value from old sample, recent sampling shows no problem, only sampling event with detection in well, other sample from same sampling event showed no detection. Unfiltered sample showed problem, filtered sample from same sampling event showed undetect (no turbidity data available). Remainder of detections reported with "L" and/or "B" qualifier indicating the detection was below the contract required detection limit but detectable by the labs instruments....only a problem if treat "L" or "B" qualified data as a detection.
Arsenic	•		1296 detections above MTCA-B value of 0.05 ppb; Detections from wells where most recent values are just above background and are one to two years old.
Carbon tetrachloride	•		54 detections above MTCA-B value of 0.337 ppb; Reasons for removing detections from consideration - single detection, value from old sample, recent sampling showed no problem. Remainder of detections reported with "L" qualifier indicating the detection was below the contract required detection limit but detectable by the labs instruments.
Chromium		•	354 detections above MTCA-B value of 80 ppb; Detections indicate a problem in both the unfiltered and filtered samples from one well associated with the single-shelled tanks - Area A-AX and should be addressed in the associated TSD.
Manganese	•		157 detections above MTCA-B value of 80 ppb; Detections indicate a problem in both the unfiltered and filtered samples from wells associated with the 216-B-3 Pond and should be addressed in the associated TSD.
Strontium-90	•		49 detections above MTCA-B value of 8 pCi/L; Detections indicate a problem in two wells associated with the 216-A-36-B Crib and should be addressed in the associated TSD.
Vanadium	•		30 detections above MTCA-B value of 112 ppb; Detections indicate a problem in both the unfiltered and filtered samples from one well located down gradient from the 216-A-37-2 Ditch.
Iodine-129	•		50 detections above MCL value of 0.48 pCi/L.
Tritium	•		3007 detections above MCL value of 20000 pCi/L.
Nitrates	•		2024 detections above MCL value of 10,000 pCi/L (as nitrogen 45,000 pCi/L as nitrate).

Table 4-6. Radionuclide Concentrations in Spring and Near-Springs River Water, Along 27.25 through 43.6 Hanford River Miles, During 1988 (page 1 of 2)

Concentration, pCi/L

Radionuclide	Average River Background (1)	Spring 27.25	Spring 27.5	River 27.5	Spring 28.1	(1st of 2) Spring 28.1
Gross Alpha	0.31±0.17	2.50±2.07	2.11±1.02	--(2)	2.32±1.07	2.62±1.12
Gross Beta	0.96±0.40	4.33±4.1	14.2±2.71	--	48±4.86	168±11
Tritium	70±6	7420±296	72000±888	26400±525	155000±1290	143000±980
Sr-90	0.10±0.02	--	-.0693±-.33	--	0.074±0.35	0.79±0.11
Co-60(D)	0.0009±.0011	--	1.07±3.68	--	4.72±4.76	4±1.8
Zn-65	--	--	-4.41±10.1	--	1.52±14.4	-0.20±2.60
Tc-99	--	--	48.4±1.76	--	223±2.95	228±3
Ru-106	--	--	3.22±39	--	-2.65±41.4	3.0±7.6
Sb-125	--	--	--	--	--	--
Cs-137(D)	0.0028±.0011	--	0.63±2.78	--	-3.74±3.31	-0.5±1.1
234U	0.20±0.03	--	--	--	--	--
235U	0.006±0.003	--	--	--	--	--
238U	0.17±0.02	--	--	--	--	--
U Total	0.37±0.04	--	--	--	--	--

Concentration, pCi/L

Radionuclide	(2nd of 2) River 28.1	Spring 28.5	Spring 38.25	Spring 38.8	Spring 41.5-.8	Spring 42.0
Gross Alpha	--	1.49±0.91	2.91±1.14	2.28±1.11	3.25±1.49	4.42±1.18
Gross Beta	--	45±4.65	1.85±1.4	6.84±1.98	10.1±2.41	5.25±1.69
Tritium	158000±1250	145000±1250	2630±231	682±182	6580±308	1070±192
Sr-90	--	0.0014±0.33	--	--	--	--
Co-60	--	2.82±3.16	-1.06±2.03	-0.71±1.8	0.38±1.45	0.34±1.53
Zn-65	--	4.39±8.77	-4.32±5.49	-1.77±6.13	-2.14±5.79	4.63±5.12
Tc-99	--	215±2.89	--	--	--	--
Ru-106	--	24.1±28.7	-2.62±17.1	0.93±20.6	-3.9±21.8	13.2±17.0
Sb-125	--	--	--	--	--	--
Cs-137	--	-1.3±2.58	-0.58±1.41	1.37±1.79	0.45±1.76	-1.64±1.53
234U	--	--	--	--	--	2.03±0.13
235U	--	--	--	--	--	.18±.041
238U	--	--	--	--	--	1.94±0.13
U Total	--	--	--	--	--	--

NOTE: Column Spring and River Identification Numbers are in Hanford River Miles

Table 4-6. Radionuclide Concentrations in Spring and Near-Springs River Water, Along 27.25 through 43.6 Hanford River Miles, During 1988 (page 2 of 2)

Concentration, pCi/L

Radionuclide	**(1st of 2) Spring 42.1**	**(2nd of 2) Spring 42.1**	**River 42.1**	**Spring 42.3**	**Spring 43.6**
Gross Alpha	7.95±1.46	6.40±1.29	--	6.51±1.36	0.52±0.60
Gross Beta	11.6±3.3	7.31±1.94	--	9.81±2.22	4.69±1.76
Tritium	168±115	346±172	485±176	283±170	64.8±163
Sr-90	0.16±0.07	--	--	--	--
Co-60	0.25±0.3	-3.36±2.74	0.61±1.42	1.61±2.18	0.41±1.29
Zn-65	-0.90±1.60	5.44±7.98	1.68±5.80	2.96±7.25	-2.21±6.05
Tc-99	--	--	--	--	--
Ru-106	-0.3±6.1	9.29±21.7	9.6±17.4	-16.8±27.1	11.3±19.9
Sb-125	--	--	--	--	--
Cs-137	0.4±0.6	-0.44±1.99	-0.94±1.25	-0.36±2.08	0.49±1.65
234U	4.26±0.20	4.48±0.20	4.28±0.21	3.48±0.18	--
235U	0.20±0.04	0.36±0.056	0.31±.056	0.24±0.048	--
238U	4.48±0.2	4.6±0.20	3.95±0.20	3±0.17	--
U Total	--	--	--	--	--

(1) Average Background ± standard error of the calculated mean. Radionuclides measured for background use the continuous system and are identified in these tables as those with the dissolved (D) fraction after the radionuclides name. All other backgrounds are based on samples collected by the composite system (where additional information shows Co-60 has a background of 0.0006±0.0003 and Cs-137 has a background of 0.0018±0.0005 pCi/L).

(2) Dashes (--) indicate no values provided in the report.

Data taken from: Dirkes (1990)

NOTE: Column Spring and River Identification Numbers are in Hanford River Miles

Table 4-7. Non-Radionuclide Concentrations, above detection levels, in Spring and Groundwater, along 27.5 through 43.6 Hanford River Miles, During 1988

Concentration, ppb

Contaminant	Detection Limit (1)	River Background (2)	Spring 27.5	Spring 28.1	Spring 42.1	Spring 42.3	Spring 43.6
Strontium	20	--	--	333	109	119	--
Zinc	5	--	--	17	23	10	--
Calcium	50	21657	--	45520	24289	26492	--
Barium	6	33	--	60	48	54	--
Sodium	200	2452	--	21435	10269	12320	--
Copper	10	--	--	< 10	34	< 10	--
Vanadium	5	<5	--	16	<5	<5	--
Aluminum	150	< 150	--	306	< 150	< 150	--
Manganese	5	14	--	24	<5	5	--
Potassium	100	811	--	2784	2493	2461	--
Iron	30	160	--	451	87	121	--
Magnesium	50	4777	--	13127	4584	4821	--
Chloroform	5	--	--	<5	24	19	--
Total Organic Carbon	--	1281	--	433	656	762	--
Cyanide	10	--	--	10.5	< 10	< 10	--
Total Carbon	2000	13320	--	25460	14298	15718	--
Total Organic Halogen	10	8(3)	--	< 10	30.2	24.9	--
Nitrate(4)	500	<500	12713	31040	1,697	9,183	9166
Sulfate	5000	10336	33410	38360	17423	16320	14651
Chloride	5000	895	6390	9110	7500	13470	2573

(1) Special Note: Chromium was under the detection limit of 10 ppb at springs 28.1, 42.1 and 42.3.
(2) Columbia River background sample is from the Priest Rapids Dam Location.
(3) Although the report states that Total Organic Halogen (TOX) background was 8 (Table 12), the appendices state that the lab was only able to detect to 10 ppb (Table B.7). The author of this section therefore was unable to conclude what this data for TOX meant.
(4) Nitrate at River 28.1 is 31,290 and at River 42.1 is 1,697 ppb.

Data taken from: Dirkes (1990)

Table 4-8. Radionuclide Regulatory Levels of Concern

Concentration, pCi/L

Radionuclide	40 CFR and WAC 246-290-310 Maximum Contaminant Level	DOE Order 5400.5 Ingested Water Derived Concentration Guides
Alpha	15	RNL (1)
Beta	50(2,3)	RNL
^{3}H	20,000(2)	2,000,000
^{60}Co	100(3)	10,000
^{65}Zn	--	9,000
^{90}Sr	8(2)	1,000
^{99}Tc	900(3)	100,000
^{106}Ru	30(3)	6,000
^{125}Sb	300(3)	60,000
^{129}I	1(3)	500
^{137}Cs	200(3)	3,000
^{234}U	--	500
^{235}U	--	600
^{238}U	--	600
U-Total	--	RNL

(1) RNL - Radionuclide Not Listed
(2) Beta and gamma radioactivity from man made radionuclides. Annual average concentration shall not produce an annual dose from man made radionuclides equivalent to the total body or any internal organ dose greater than 4 mrem/yr. Compliance may be assumed if annual average concentrations of total beta, tritium, and strontium-90 are less than 50, 20,000, and 8 pCi/L, respectively.
(3) Average annual concentrations assumed to produce a total body organ dose of 4 mrem/yr (for the purposes of the comparison, these numbers were taken from the Dirkes and Hans [1995]).

Table 4-9. Non-Radionuclide Regulatory Levels of Concern

Concentration, mg/l or ppm

Contaminant	40 CFR 141 MCL(1)	40 CFR 141 MCLG(2)	WAC 246-290-310 Primary MCL	40 CFR 143 and WAC 246-290-310 Secondary MCL
Strontium	--(3)	--	--	--
Zinc	--	--	--	5.0
Calcium	--	--	--	--
Barium	2.0	2.0	2.0	--
Sodium	--	--	(4)	--
Copper	--	1.3	(4)	1.0
Vanadium	--	--	--	--
Aluminum	--	--	--	0.05 to 0.2
Manganese	--	--	--	0.05
Potassium	--	--	--	--
Iron	--	--	--	0.3
Magnesium	--	--	--	--
Chloroform	--	--	--	--
Cyanide	0.2(5)	--	0.2	--
Nitrate	10.0(6)	10.0(6)	10.0(6)	--
Sulfate	--	--	--	250.0
Chloride	--	--	--	250.0

(1) MCL=Maximum Contaminant Level
(2) MCLG=Maximum Contaminant Level Goal
(3) Dashes (--) indicate chemical not listed in the regulations appearing in the columns of this table.
(4) Although the state board of health has not established MCLs for copper and sodium, there is enough public health significance connected with these substances to require inclusion in inorganic chemical and physical source monitoring.
(5) as free cyanide
(6) as Nitrogen

Table 4-10. Hanford Site Radionuclide Concentrations Measured in, Columbia Riverbank Spring Water and Columbia River Water Along Cross Sections, During 1994, at the Old Hanford Townsite

Concentration, pCi/L

Radionuclide	Columbia Riverbank Spring Water Maximum	Columbia River Water Along Cross Sections Maximum
Alpha	4.88 ± 2.17	--(1)
Beta	7.68 ± 2.20	--
^{3}H	173,000 ± 12,700	3,280 ± 277
^{129}I	0.0435 ± 0.347	--
^{90}Sr	0.123 ± 0.167	0.141 ± 0.076
^{99}Tc	54.4 ± 6.29	--
^{234}U	--	0.263 ± 0.068
^{235}U	--	0.025 ± 0.034
^{238}U	--	0.191 ± 0.057
U-Total	4.03 ± 0.58	0.434 ± 0.136

(1) Dashes (--) indicate no values provided in the report.

Data taken from: Dirkes and Hans (1995)

Table 4-11. Hanford Site Radionuclide Concentrations Measured in, Columbia Riverbank Spring Water and Columbia River Water Along Cross Sections, During 1994, at the 300 Area

Concentration, pCi/L

Radionuclide	Columbia Riverbank Spring Water Maximum	Columbia River Water Along Cross Sections Maximum
Alpha	110 ± 21.2	--(1)
Beta	20.6 ± 3.3	--
^{3}H	11,300 ± 954	66.6 ± 11.1
^{129}I	0.00439 ± 0.00021	--
^{90}Sr	0.198 ± 0.107	0.106 ± 0.048
^{99}Tc	12.7 ± 2.04	--
^{234}U	--	0.356 ± 0.123
^{235}U	--	0.117 ± 0.132
^{238}U	--	0.287 ± 0.197
U-Total	113 ± 13	0.669 ± 0.538

(1) Dashes (--) indicate no values provided in the report.

Data taken from: Dirkes and Hans (1995)

Table 4-12. Ambient Water Quality Criteria

CONTAMINANT	FRESH WATER CHRONIC CRITERION	HUMAN HEALTH WATER AND ORGANISM INGESTION	HUMAN HEALTH ORGANISM INGESTION ONLY
Sr	NL	NL	NL
Zn	73.57μg/L	NL	NL
Ca	NL	NL	NL
Ba	NL	1,000μg/L	NL
Na	NL	NL	NL
Cu	8.18μg/L*	1,300μg/L	NL
V	NL	NL	NL
Al	***	***	***
Mn	NL	50 μg/L	100 μg/L
K	NL	NL	NL
Fe	1,000 μg/L	300 μg/L	NL
Mg	NL	NL	NL
Chloroform	1,240 μg/L	5.7 μg/L**	470 μg/L**
CN	5.2 μg/L	700 μg/L**	21,500 μg/L**
Nitrate	NL	10,000 μg/L	NL
Sulfate	NL	NL	NL
Chloride	230,000 μg/L	NL	NL

NL No value listed under either Federal guidelines (EPA's Quality Criteria for Water [WAC 173-201]) or State of Washington's promulgated water quality standards (WAC 173-201-047).

* The water quality criteria for protection of aquatic organisms are based on the hardness of the receiving stream. The hardness used to calculate the fresh water chronic criteria for zinc and copper in this tables was 65 mg/L (as $CaCO_3$), which approximates the mean hardness of the Columbia River in the vicinity of Hanford, as reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hans 1995).

** These values are based on a recalculation of the criteria originally published in EPA's *Quality Criteria for Water* (1986), using IRIS data as of 9/90.

*** The values for Al need to be looked by in the Gold Book.

5.0 SUMMARY AND CONCLUSIONS

5.1 POTENTIAL CORRECTIVE ACTIONS

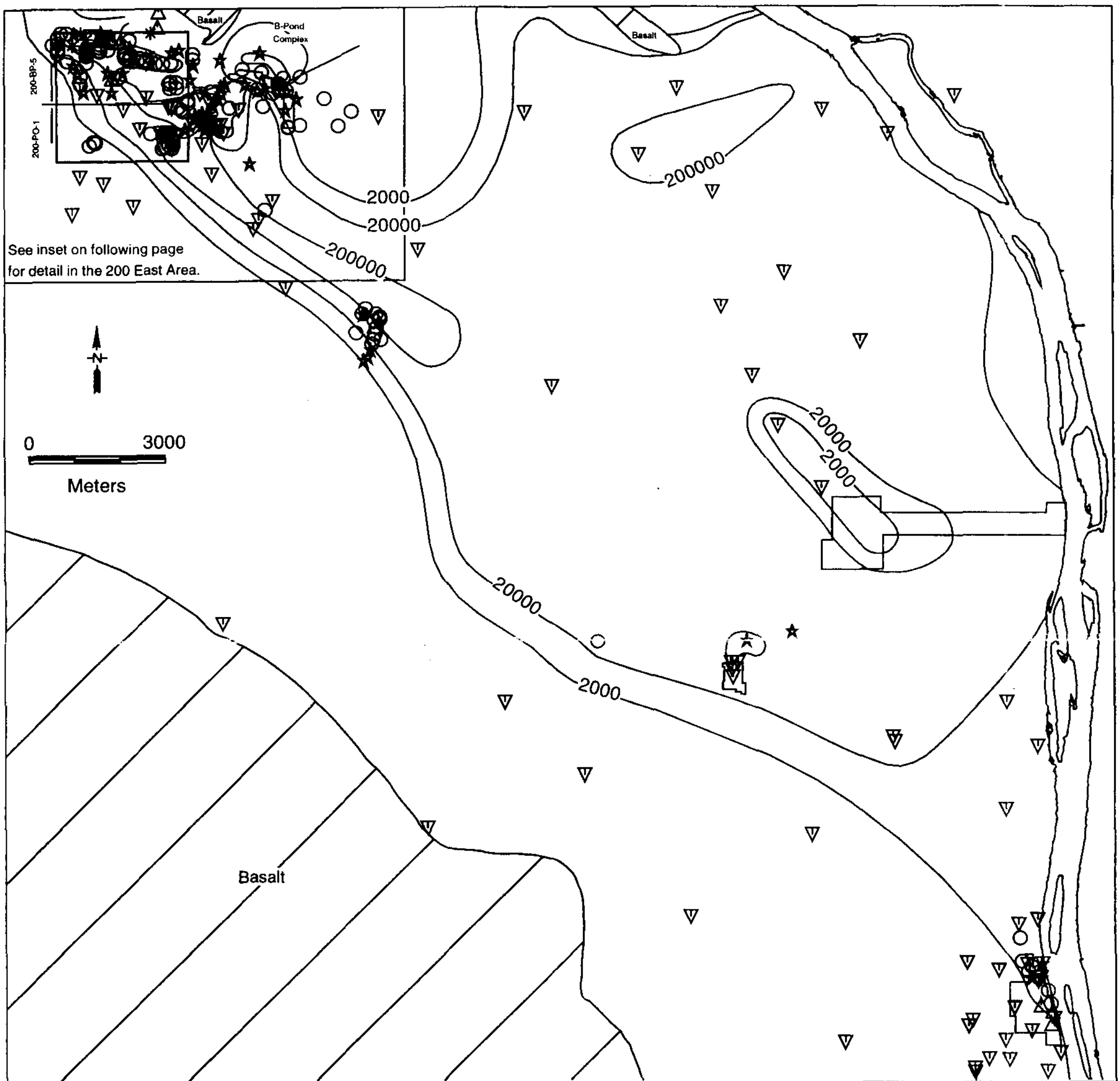
The data presented and evaluated in this report will support the generation of a CMS report in the future. The CMS report will develop and evaluate potential corrective measures to be taken to address 200-PO-1 COPC.

Currently feasible remedial actions for tritium are unavailable; however, technology development is reviewed annually under Tri-Party Agreement Milestones M-25-05A through M-25-05Z. Any new information on treatment of tritium will be incorporated in the CMS. Several treatment technologies are available for treating iodine-129; however, treatment of the low concentrations in the operable unit is uncertain. Treatment technologies are being identified and evaluated in an iodine-129 study as part of Tri-Party Agreement M-15-81b. The results of the study will be incorporated in the CMS. Nitrate treatment is being studied through different programs at Hanford, including biodenitrification treatability testing. Information from other treatability studies, feasibility studies, ERAs, and IRMs will be incorporated as available in the CMS. The other constituents, such as the chromium, strontium-90, and other metals, are limited in extent in the operable unit. The chromium and strontium-90 are being evaluated in other operable units at Hanford as part of feasibility studies, treatability studies, ERAs, and IRMs. This information will also serve as a basis for evaluation of these constituents in the CMS.

5.2 NEED FOR ADDITIONAL INVESTIGATIONS/MONITORING

Based on the review of existing data, no additional characterization investigations are recommended at this time. Treatability testing for treatment of the operable unit contaminants may be required; however, the need for this testing is also being evaluated through supporting studies. Treatability test requirements will be further evaluated in the CMS using results of the RFI, other studies, and the detailed analysis of alternatives. Additional investigations necessary for design will be identified during the CMS and initial design phase.

An issue identified in the DQO process was the need to coordinate monitoring efforts between the existing groundwater monitoring programs and the monitoring requirements for 200-PO-1 Operable Unit. A summary of current programs is included in Section 2.0. Figure 5-1 shows the 1995 groundwater monitoring for the operable unit. The CMS report will include an evaluation of the monitoring needs for the operable unit as part of the detailed analysis of alternatives. In addition, the Groundwater Sitewide Strategy document is assessing groundwater monitoring for the Hanford Site. The 200-PO-1 monitoring evaluation will be coordinated with the strategy evaluation in terms of defining goals and objectives for groundwater monitoring. The information developed as part of the strategy will be incorporated as practicable in the monitoring evaluation for the CMS. The CMS will recommend a monitoring system for the operable unit and identify points of potential integration between programs. The CMS will serve as a starting point for integrating the monitoring requirements for all the programs such that the objectives of all programs are adequately addressed and that costs are cut by only performing necessary monitoring.



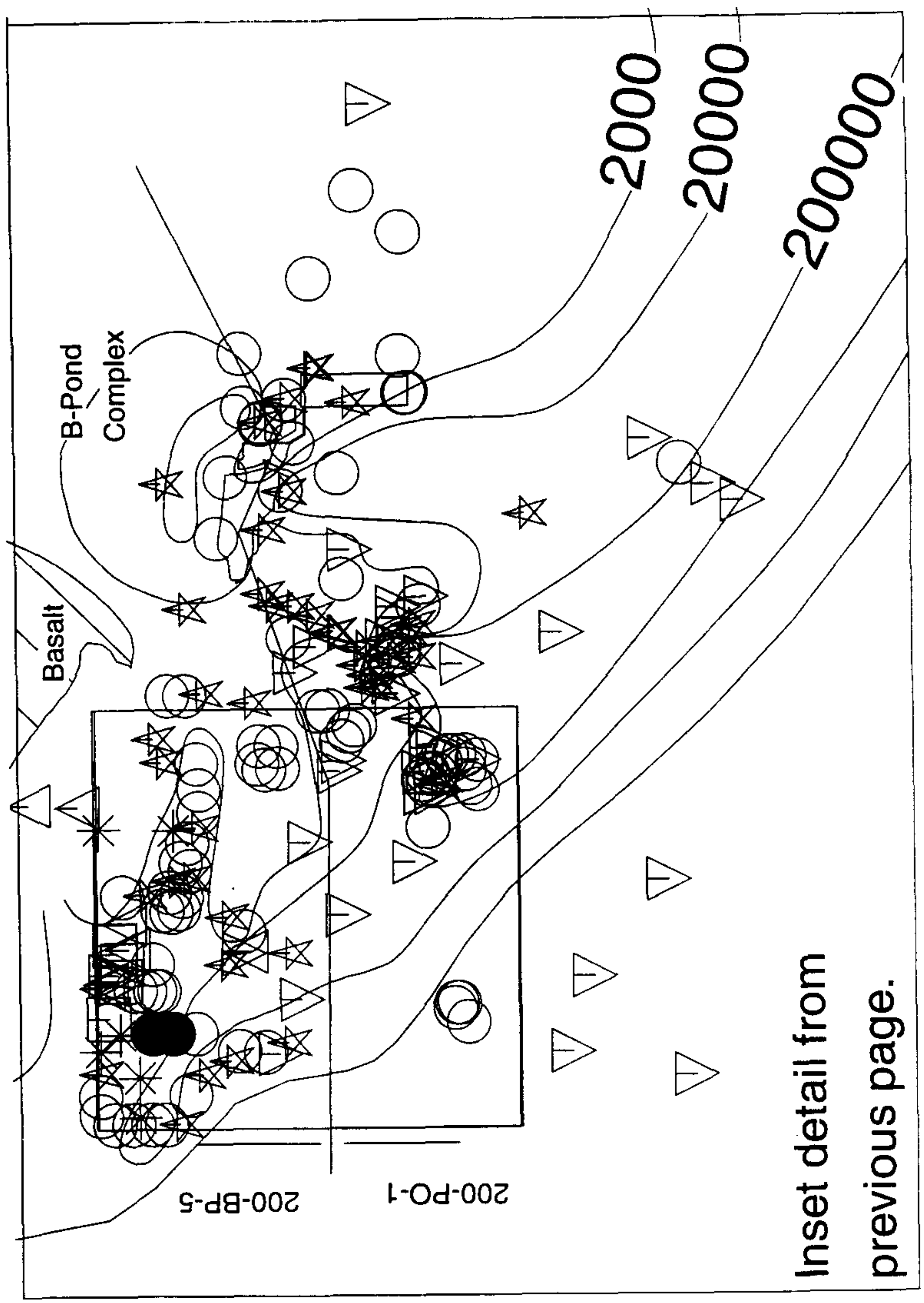
FY95 Monitoring Network Sampling in the 200-PO-1 Operable Unit

- ○ RCRA/Operational Program Well
- △ CERCLA Program Well
- ▽ Sitewide Program Well
- ● RCRA/Operational/CERCLA Cosample Well
- ★ RCRA/Operational/Sitewide Cosample Well
- ☐ CERCLA/Sitewide Cosample Well
- ✳ RCRA/Operational/CERCLA/Sitewide Cosample Well

1994 Tritium contours are included for information.

Figure 5-1. FY95 Monitoring Network Sampling in the 200-PO-1 Operable Unit (page 1 of 2)

Figure 5-1. FY95 Monitoring Network Sampling in the 200-PO-1 Operable Unit (page 2 of 2)



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APPENDIX A

DQO SUMMARY

1.0 INTRODUCTION

This DQO appendix summarizes the DQO process implemented during planning stages for RFI/CMS activities associated with the 200-PO-1 Groundwater Operable Unit. The purpose of the DQO process was to support the preparation of an RFI/CMS work plan (Tri-Party Agreement Milestone M-13-10) establishing the data needs to support the ultimate selection of an appropriate corrective measure. The DQO process was completed consistent with *Guidance for the Data Quality Objectives Process* (EPA 1994).

2.0 PURPOSE AND SCOPE

The DQO process aids in the planning of environmental data collection efforts by establishing the framework to make defensible decisions in an effective and efficient manner. The DQO guidance document (EPA 1994) recommends the following seven steps for the DQO process:

1) state the problem
2) identify the decision
3) identify inputs to the decision
4) define the study boundaries
5) develop a decision rule
6) specify limits on decision errors
7) optimize the design for obtaining data.

The guidance has been used to organize meetings, focus the collection of background information, and facilitate communication between technical experts, program managers and decision makers. The 200-PO-1 DQO process is considered to be a pilot project for DOE. The 200-PO-1 Groundwater Operable Unit was selected as a pilot project because it was considered to be straight-forward, did not involve major policy issues, and had sufficient time to conduct the DQO process. The implementation of the current guidance and documentation of the decision making process will be used as a case study for future DOE DQO activities.

The DQO process for the 200-PO-1 Operable Unit included the following activities:

- ***Identification of Participants*** - The DQO participants were selected to represent primary decision makers (EPA, DOE, Ecology), technical contractors and an independent party as a facilitator. The participants are identified on Figure A-1. The participants were selected based on their relationship to the decision making process for the 200-PO-1 Operable Unit as well as their value as technical contributors to the RFI/CMS activities for the operable unit. Participants were limited to a minimum number to accommodate efficient decision-making.

- ***Facilitator Interviews*** - The DQO facilitator conducted interviews to receive preliminary input on the DQO process from each participant on an individual basis prior to any meetings. Input included major concerns related to the DQO process, potential data needs and perceived end products of the DQO process.

- ***Data Compilation*** - Prior to the initial DQO meetings the existing data related to the 200-PO-1 Operable Unit were compiled and evaluated to identify potential data gaps. The existing data were reviewed by the DQO participants to allow all decision makers to become familiar with the existing data base. The primary data resources were the *200 East Groundwater Aggregate Area Management Study Report* (DOE-RL 1992a) and the HEIS database. Substantial data collection has been ongoing for many years through a number of groundwater monitoring programs; therefore, significant amounts of data were available.

- ***DQO Meetings*** - A series of meetings was held to complete the DQO process. The initial meetings consisted of reviewing and discussing existing data to identify any potential data gaps. Additional data gathering and evaluation was performed as needed in support of the meetings. The data were evaluated considering spatial and temporal distribution of data collection activities including identification of analytes and locations of monitoring wells.

  Analytical data were reviewed through trend analysis (concentration vs. time) and comparison to regulatory levels of concern. The data evaluation allowed the determination of the quantity and quality of existing data. Potential data gaps were identified, the impacts of those data gaps were assessed and resolution to the data gaps was determined.

  As the decision makers identified additional data needs, the technical contributors provided the requested information in a timely manner to facilitate efficient decision making. Meeting minutes documented the discussions during the DQO process as well as key decisions reached by the participants.

- ***Informed Decisions*** - As a result of the comprehensive review and evaluation of existing data by all participants, the necessary decision-making tools were made available to define the RFI/CMS activities for the 200-PO-1 Operable Unit. The responsible party (DOE), was able to satisfy the information needs of the regulatory agencies (EPA, Ecology) in a timely manner such that defensible decisions concerning data needs could be made. Prior to obligating resources to a rigorous data collection program, the DQO process provided the decision makers with the information necessary to make informed decisions resulting in savings of schedule and budget.

3.0 200-PO-1 DQO PROCESS

The 200-PO-1 DQO process was patterned after the seven step process outlined in EPA's guidance (EPA 1994). The following sections describe the general purpose of each DQO step and the results of the process as applied to the 200-PO-1 Operable Unit.

- **STEP 1 - STATE THE PROBLEM**: The purpose of step 1 is to clearly define the problem or problems to be addressed by the DQO process. The problem statements for 200-PO-1 are as follows:

  1. Contaminants above regulatory requirements are present in the groundwater.
  2. Contaminants have reached the Columbia River.
  3. Assess the adequacy of existing data for developing/refining the conceptual model.
  4. Assess the adequacy of existing data for performing risk evaluation.
  5. Assess the adequacy of existing data for identifying and evaluating corrective action measures.

- **STEP 2 - IDENTIFY THE DECISION**: The purpose of step 2 is to define the decision or decisions to be made through the DQO process. The decisions are the study questions which are answered in support of problem statement (step 1) resolution. Decision statements identify alternative actions that result from decisions. The decision statements, the applicable problem statements, and the results for 200-PO-1 Operable Unit are defined in Table A-1.

- **STEP 3 - IDENTIFY INPUTS TO THE DECISION**: The purpose of step 3 is to identify the informational inputs used to resolve the decision statements. This step identifies existing information sources as well as potential additional data gathering needs. A list of inputs for the DQO process for the 200-PO-1 Operable Unit is included in Table A-2. A large amount of groundwater sampling data was available. As part of the DQO process, data from 204 wells for the last 10 years were reviewed. The DQO participants agreed that the data were sufficient and that trend analysis could be used instead of statistical analysis. In addition, statisticians evaluated the existing data base and concurred that a trend analysis would provide the best method of qualitatively predicting plume movement. They agreed further statistical analysis of the data was not warranted due to the large data set available. Table A-3 provides a summary of data screening performed during the DQO process. Figure A-2 is an example trend plot.

- **STEP 4 - DEFINE THE STUDY BOUNDARIES**: The purpose of step 4 is to define the spacial and temporal boundaries of the decision statements supporting problem resolution. Time and geographical boundaries for the 200-PO-1 Operable Unit are as follows:

  - **Time Boundaries**: The Tri-Party Agreement sets 2018 as the completion date for remedial actions for the operable units (Milestone M-16-00) and 2028 as the completion date for treating the tank wastes. The participants to the DQO process felt that current conditions, conditions in 2018, and conditions in 2128 (100 years past waste tank closure) should be evaluated. The CMS will calculate risk values for these time frames as supported by modeling (Table A-4).

- **Geographic Boundaries**: The geographic boundaries of the operable unit were determined to be the boundaries of the tritium plume emanating from the southern half of 200 East Area (Figure A-3). The 2,000 pCi/L plume boundary will serve as the outline of the area to be considered in the RFI. A hard line separates the 200-BP-5 and 200-PO-1 Operable Units within the 200 East Area. The area on the plateau is considered industrial for the foreseeable future. The area off the plateau could potentially have unrestricted future use. In addition, the Columbia River is located to the east and south of the operable unit. Contaminants, especially tritium and iodine-129, have reached the river.

- **STEP 5 - DEVELOP A DECISION RULE and STEP 6 - SPECIFY LIMITS ON DECISION ERROR**: The purpose of step 5 is to develop a logical basis for choosing among alternative actions identified by the DQO process. The purpose of step 6 is to specify tolerable limits which are used to establish performance goals. The decision rules and associated uncertainties are listed in Table A-5. Figure A-4 illustrates the decision flowchart for determining contaminants of concern for the operable unit.

- **STEP 7 - OPTIMIZE THE DESIGN FOR OBTAINING DATA**: The purpose of step 7 is to optimize the data collection activities if necessary. Data compilation conducted as part of the DQO process accomplished many of the goals that would have been included in the work plan. As a result, the work plan was deemed unnecessary, saving time and money, and significantly progressing the RFI/CMS activities for the operable unit.

Through the DQO process, project scheduling was optimized to fully utilize pertinent information from other projects. This coordination of efforts results in both time and cost savings. Potential redundant or overlapping scopes of work were avoided by utilizing inputs from other projects.

4.0 SUMMARY OF KEY DECISIONS

The DQO process for 200-PO-1 resulted in a number of key decisions associated with the RFI/CMS activities for the operable unit. These are detailed in the following sections.

4.1 RFI REPORT

The most significant decision from the DQO process was to eliminate the requirement to prepare an RFI/CMS work plan and to proceed directly to preparation of an RFI report. The key decision makers decided that the information available for the operable unit was sufficient to define the conceptual model and to support a CMS report. The operable unit information was summarized in preparation for and as part of the DQO process. The RFI report will formally present the operable unit data, conceptual model, and results of the DQO process. An annotated outlined developed during the DQO process for the RFI report is given in Table A-6.

To formalize the decision to prepare the RFI report and to assign new Tri-Party Agreement milestones to the project, a Tri-Party Agreement change form was submitted and approved (Figure A-5). This change form eliminated Milestone M-13-10 which required the submittal of a work plan by October 31, 1995 and replaced it with the following milestones:

- M-15-25: Submit a draft RFI report to DOE, EPA, and Ecology for concurrent review by December 31, 1995.

- M-15-25A: Submit a draft CMS report to DOE, EPA, and Ecology for concurrent review by July 31, 1996.

- M-15-25B: Submit the documentation to include the operable unit in the RCRA permit modification process.

The scope of the RFI includes the following subtasks:

- Evaluation of the contaminant plumes associated with the operable unit including data screening and evaluation, identification of contaminants of potential concern, and plume mapping.

- Evaluation of any contaminant plumes associated specifically with TSDs located above the 200-PO-1 groundwater including data screening and evaluation and identification of contaminants of potential concern which may differ from the plume evaluation.

- Trend analysis to qualitatively describe the movement of the contaminants; this evaluation will include time versus concentration curves and historical plume mapping to show movement.

- Evaluation of current groundwater monitoring programs including a minimum required monitoring plan for 200-PO-1 and an evaluation of potential integration points among the programs.

The RFI report will be submitted in draft form to DOE, EPA, and Ecology for a concurrent review. During the RFI preparation, any additional data gaps not currently identified will be presented and evaluated for potential impacts. Should additional data gathering be needed, a phase II investigation could be conducted as necessary.

4.2 PUBLIC FACT SHEET

The RFI/CMS work plan is generally the first opportunity for public involvement in the RFI/CMS. Because the Tri-Party Agreement change form eliminated the work plan for the operable unit, the key-decisions makers in the DQO process decided to develop a fact sheet. This fact sheet will serve as notification and justification to the public for the change in the process and detail additional opportunities in the process for public involvement. The fact sheet will be developed by DOE, EPA, and Ecology. (Subsequent to the DQO process, DOE and the regulators decided not to issue the fact sheet at this time.)

4.3 CMS REPORT

The participants in the DQO process decided that a CMS report could be prepared using existing information and information currently being prepared through other projects. An evaluation of treatment technologies for iodine-129 is currently being conducted under Tri-Party Agreement M-15-81B; this information is in direct support of 200-PO-1 and other 200 Area operable units. Information on treatment technologies for tritium is presented annually through milestones M-25-05A through Z. Other constituents, such as chromium and strontium-90, have been evaluated on site for other projects. Hanford Site groundwater modeling for the larger plumes is being conducted as part of the *Hanford Site Groundwater Strategy* (DOE/RL 1995) document revision. This modeling effort will include the major 200-PO-1 plumes (tritium, nitrate, and iodine-129) and will be used to support a limited risk assessment. Therefore, the scope of the CMS is to summarize and refer to these other documents with evaluation of treatment alternatives for those constituents not addressed through other arenas. Human health risks associated with the operable unit plumes will be estimated for areas on and off the plateau and for current and future contaminant concentrations. The schedule for the CMS will allow for completion of the supporting documents. The document will be submitted to DOE, EPA, and Ecology for concurrent review.

4.4 SITEWIDE RCRA PART B PERMIT MODIFICATION

Because this is a RCRA past-practice unit, the parties have agreed to address the cleanup of the operable unit through the RCRA regulations. Therefore, the documentation of remedial action decisions is through permit modification. The documentation required for modifying the Hanford Site Wide Permit to include 200-PO-1 activities will be prepared to meet permit modification schedules.

4.5 COST AND SCHEDULE SAVINGS

By eliminating preparation costs for a work plan and redirecting these funds for preparation of the RFI and CMS reports, a cost savings of $145,000 was realized (i.e., the projected cost of the work plan). In addition, costs associated with any potential investigation work would not be incurred.

Net savings to the costs of preparing the RFI report were realized by utilizing the data that were assembled to prepare and conduct the DQO process. In addition, costs of preparing the RFI report and the interim CMS were substantially reduced by improving interfaces and data sharing between numerous programs. By coordinating the deliveries of the RFI and CMS, with schedules for supporting documents, scope and subsequent costs are reduced for the 200-PO-1 Operable Unit. For example, modeling results to support the evaluation of technologies in the CMS will be conducted as part of the Sitewide Strategy document. Therefore, this work scope will not be required by 200-PO-1 Operable Unit.

Schedule savings are a result of the elimination of the work plan and the subsequent acceleration of the RFI and CMS reports. The scheduled delivery of the work plan to the regulators was October 31, 1995. After reviews and comment incorporation/document revision, the investigation and RFI preparation would have been conducted in 1996 followed by a CMS sometime in late 1996 or 1997. However, by utilizing existing information, the RFI and CMS will be prepared in FY 1996.

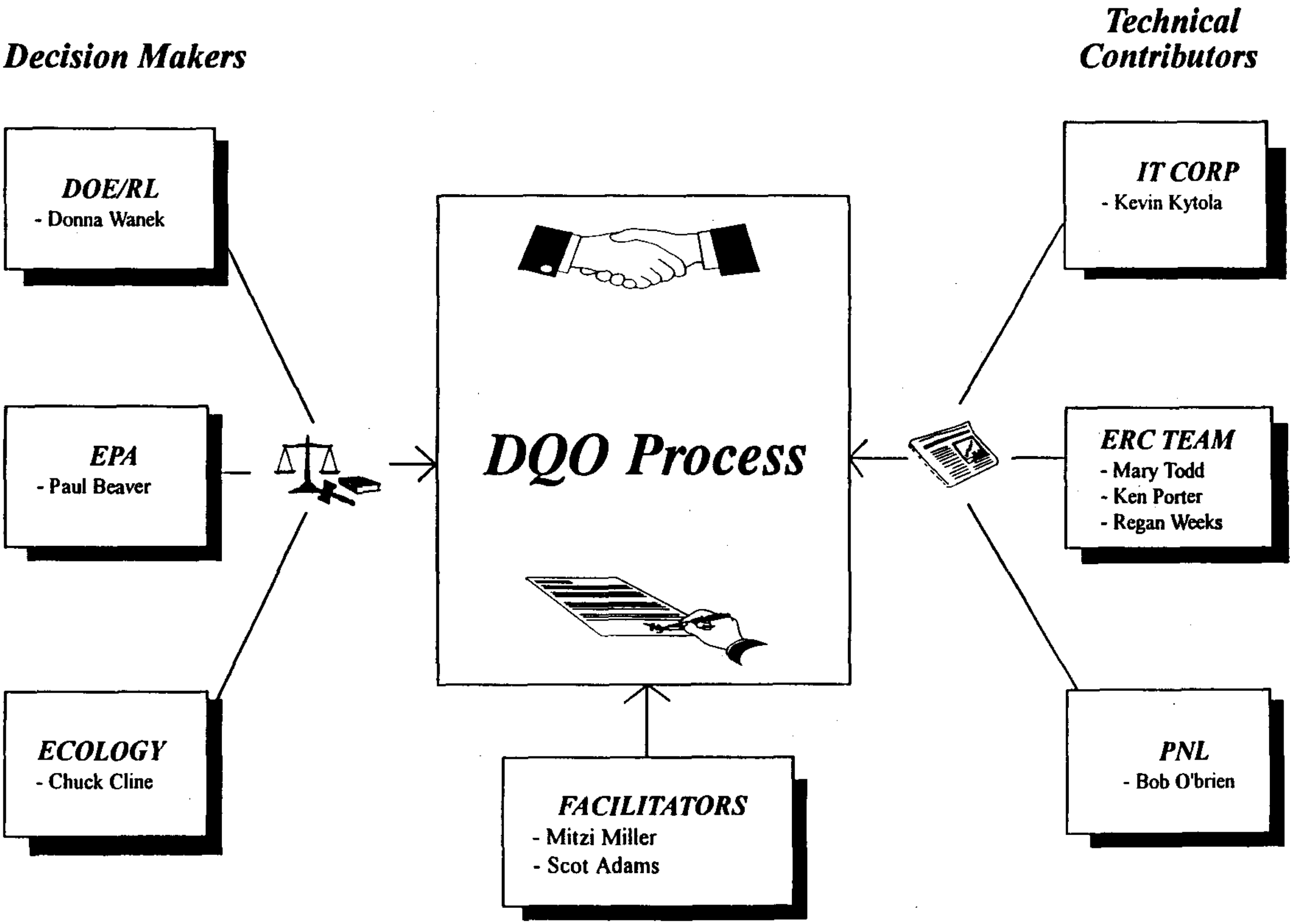


Figure A-1. DQO Process Participants

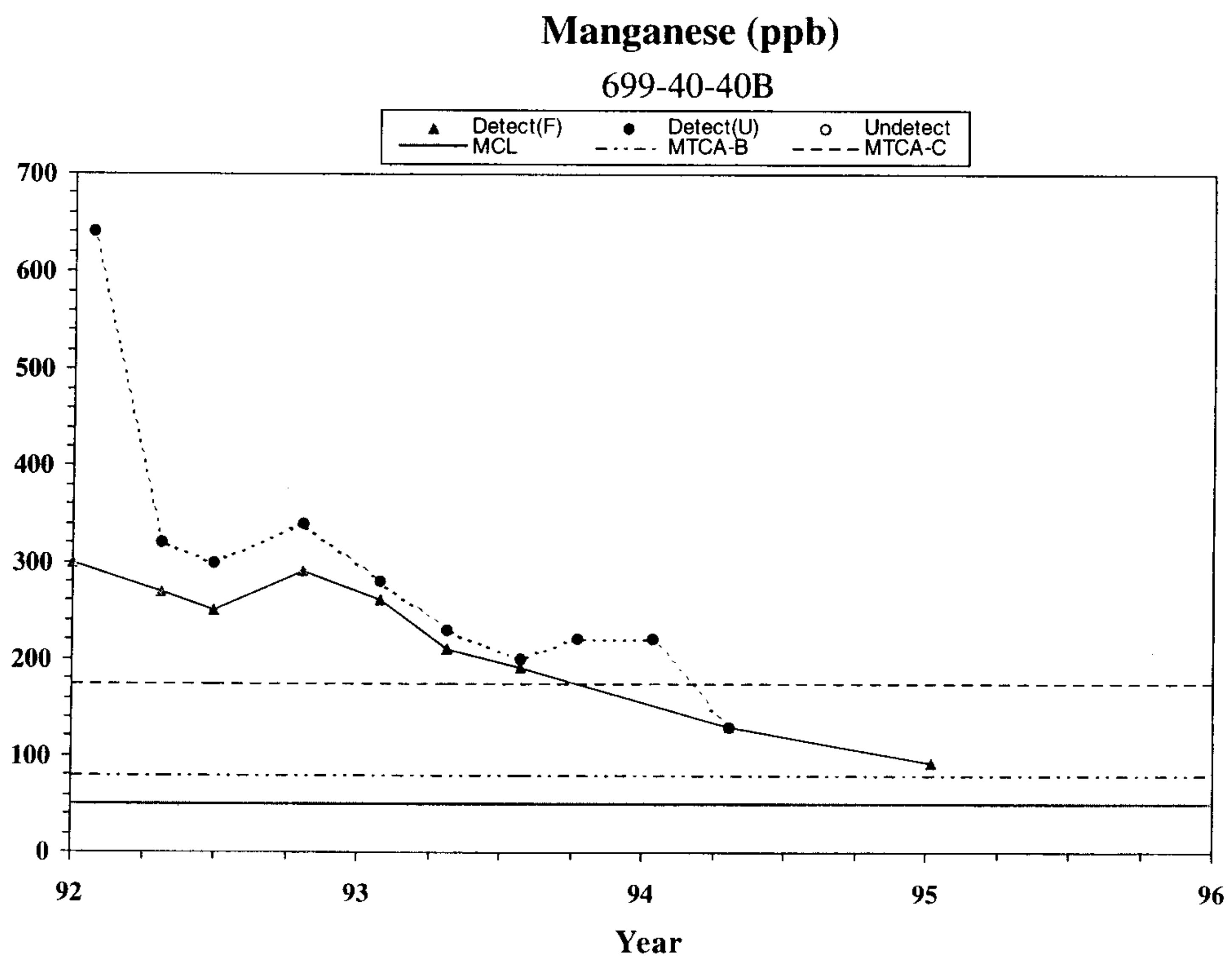
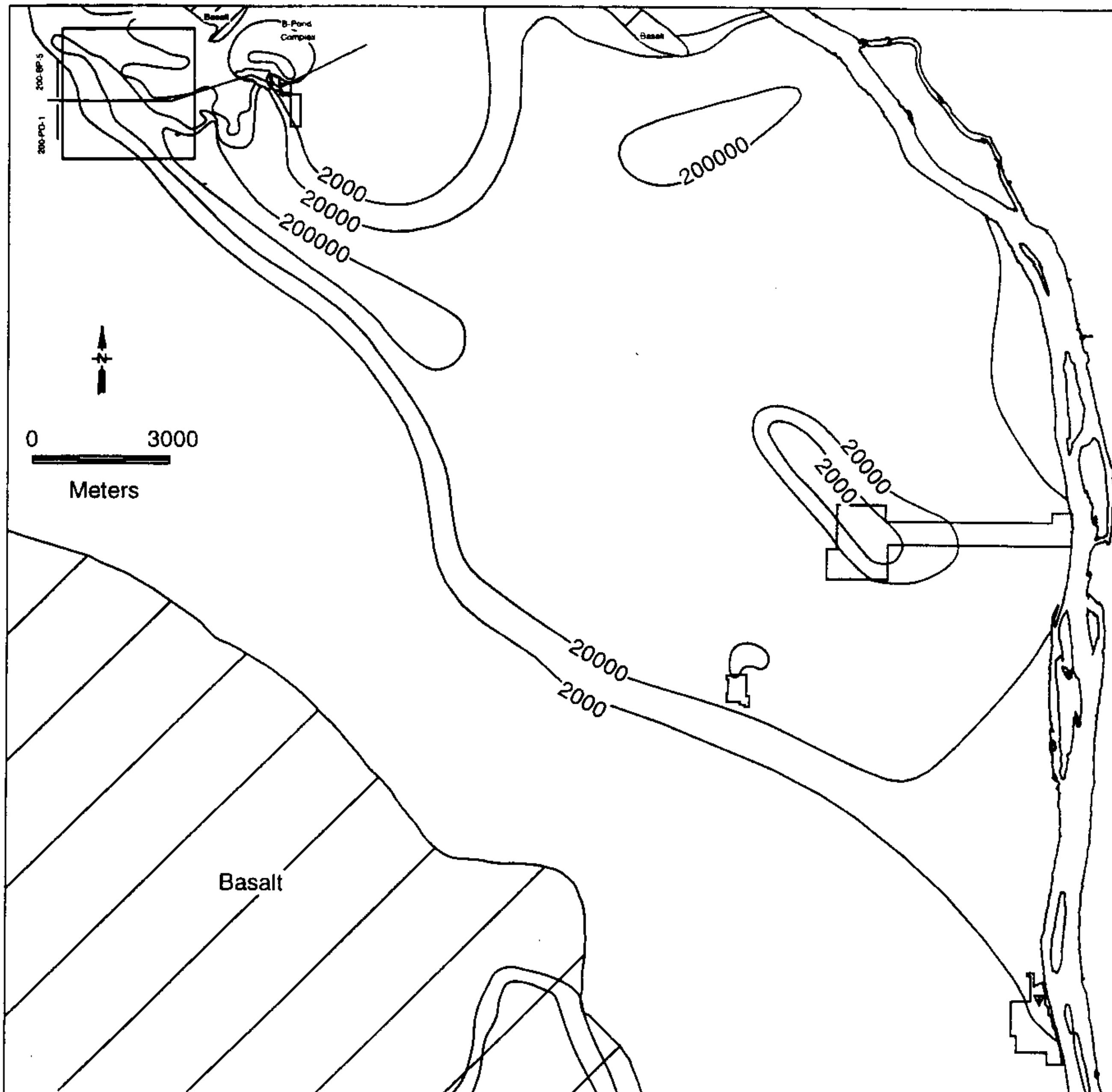


Figure A-2. Example Trend Plot

Figure A-3. 200-PO-1 Operable Unit Boundary (as defined by the 2,000 pCi/L tritium contour)



200-PO-1 Operable Unit Boundary as Defined by the Extent of Tritium Groundwater Contamination

Tritium isopleths are based on averaged result values for 1994.
Units are picoCuries-per-liter (pCi/L).

Figure A-4. Decision Logic for Determining Contaminants of Concern

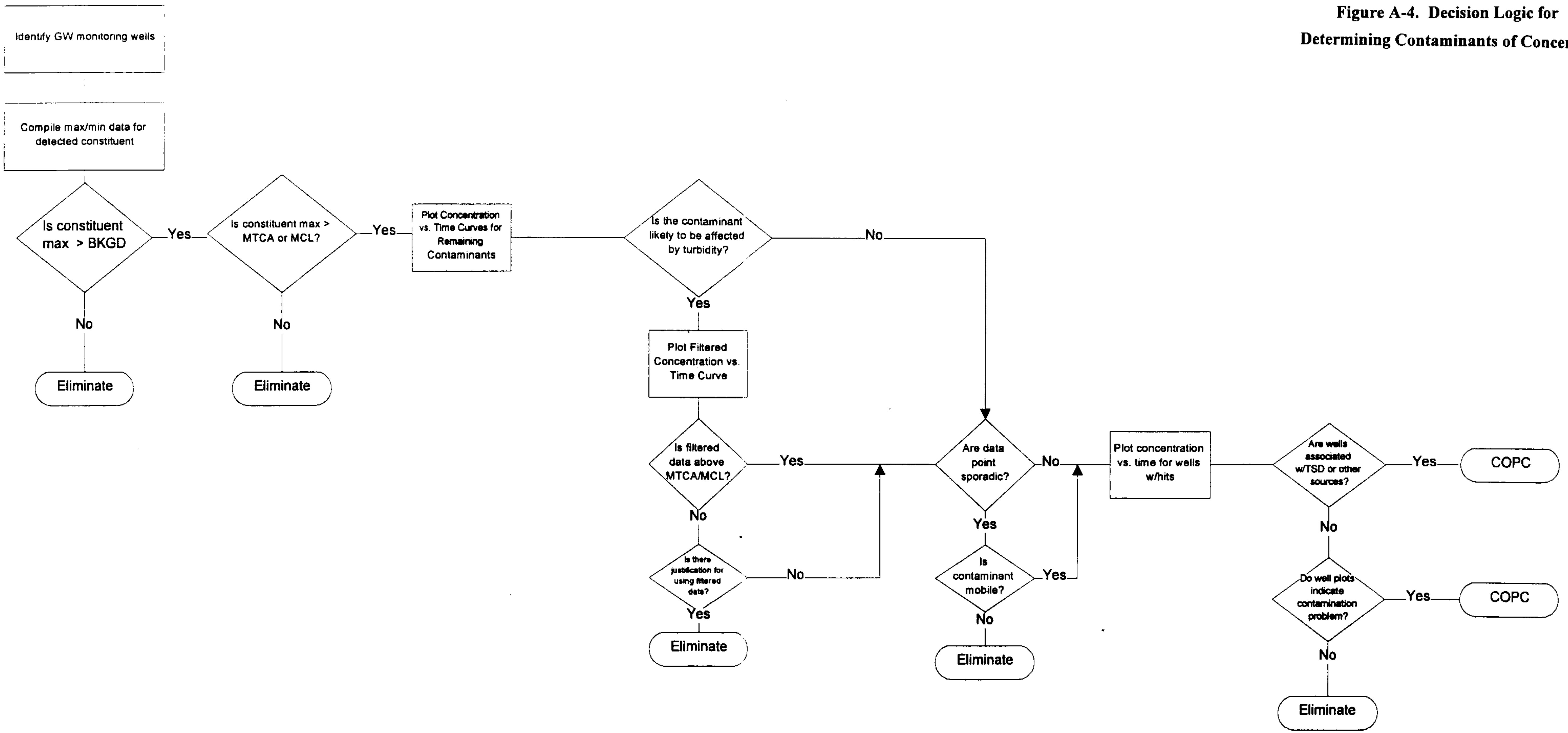


Figure A-5. Signed Tri-Party Agreement Change Form (page 1 of 2)

Change Number M-13-95-01	Federal Facility Agreement and Consent Order Change Control Form Do not use blue ink. Type or print using black ink.	Date 07/27/95

Originator
Donna Wanek

Phone
(509) 376-5778

Class of Change
[ ] I - Signatories [X] II - Project Manager [ ] III - Unit Manager

Change Title

200-PO-1 Operable Unit Permit Modification

Description/Justification of Change

Delete milestone M-13-10: "Submit 200-PO-1 RFI/CMS work plan, due October 31, 1995", and replace with the following milestones:

M-15-25: Submit 200-PO-1 Phase I RCRA Field Investigation (RFI) Report by December 31, 1995.
M-15-25A: Submit 200-PO-1 Corrective Measures Study (CMS) by July 31, 1996.
M-15-25B: Submit 200-PO-1 Permit Modification by August 30, 1996.

Impact of Change

(See impact of change on page 2)

Affected Documents

Hanford Federal Facility Agreement and Consent Order Action Plan
RFI/CMS Work Plan for 200-PO-1 Operable Unit (No longer required).
RFI/CMS Report for 200-PO-1 Operable Unit (Accelerated)

Approvals

	Date		
DOE	8/04/95	✓ Approved	___ Disapproved
EPA	8/7/95	✓ Approved	___ Disapproved
Ecology	8/4/95	✓ Approved	___ Disapproved

Figure A-5. Signed Tri-Party Agreement Change Form (page 2 of 2)

M-13-95-01
July 27, 1995
Page 2 of 2

Impact of Change:

The three parties agree that sufficient data is currently available to proceed with an RFI Report and preparation of an RFI/CMS work plan is not necessary. Boundaries of the OU will extend to the perimeter of the plume as it extends from the source(s) located at the southern portion of the 200 East area. The Southern boundary will be adjacent to the 300-FF-5 boundary but will not extend south of the 399-1-18 A, B, C well cluster.

DOE will utilize available information from the 200 East and PUREX Aggregate Area Management Study Reports, contaminant specific studies, available modeling data, and groundwater monitoring data to prepare an RFI Phase I Report and the CMS.

In order to allow opportunities for public involvement, a fact sheet will be prepared describing the changes agreed to in this change control form. When completed, the RFI Report will be available for public review, but formal comments will not be accepted. The permit modification will also allow for public involvement opportunities.

One expected result of the action is recommendations to be incorporated into the preparation of one groundwater monitoring program that will address containment migration including all TSDs located within the boundaries of the Operable Unit.

Table A-1 Step 2 - Decisions

Decision	Problem Statements Addressed	Result	Notes
Do contaminant concentrations significantly exceed regulatory levels of concern?	1, 2	Levels of concern for several constituents are exceeded. Based on the DQO process, the contaminants of interest for the operable unit are aluminum, arsenic, nickel, chromium, lead, manganese, nitrate, iodine-129, strontium-90, and tritium. Ruthenium-106 was not included; however, it was agreed that gross alpha and gross beta would be retained as analytes for sampling events.	Screening levels include MTCA B and C, Safe Drinking Water Act MCLs, and comparison to background. Maximum concentrations were used for screening then time versus concentration curves were used to further evaluate data. Additional data screening will be conducted as part of the RFI report preparation.
Are data sufficient to develop the conceptual model and to perform a risk assessment?	3, 4, 5	Data were found to be of sufficient quantity and quality to develop the conceptual model and to prepare a Phase I RFI report. Additional information required to perform a risk assessment would be collected by other projects and considered in the CMS.	Modeling conducted as part of the *Hanford Sitewide Groundwater Strategy* (DOE/RL 1995) project will be used to support the 200-PO-1 Operable Unit risk assessment, which will be conducted as part of the CMS report. Should the Phase I RFI identify additional data requirements, a Phase II investigation could be implemented.
Is groundwater modeling required?	3, 4, 5	Additional groundwater modeling was determined to be beneficial; however, this modeling will be conducted through another project. The data from the modeling effort will be used in a limited risk evaluation as part of the CMS report.	The modeling will be conducted as part of the effort to revise the Groundwater Strategy document. The 200-PO-1 Operable Unit CMS with utilize the modeling results for risk assessment.
What are current and potential future land uses?	1, 2, 3, 4, 5	The land use as describe in the Hanford Future Site Uses Working Group (HFSUWG 1992) was determined to be appropriate for the site. The site contains two distinct areas; the area on the plateau which is predominantly used for industrial purposes and the area off the plateau which could potentially have unrestricted use. Because of the proximity to the river, impacts associated with 200-PO-1 Operable Unit contaminants will be considered in the RFI report. See Table A-4.	The Columbia River is being considered for designation as a Wild and Scenic River.
Are proven remedial methods available for treating operable unit contaminants?	5	Treatment technologies for tritium are currently not feasible; technologies for treating iodine-129 are available but the low concentrations found in the operable unit may not be feasible to treat. The nitrate is treatable by technologies currently being assessed onsite. The other contaminants, such as chromium or strontium-90, are also being evaluated at Hanford. The feasibility of treating other contaminants will be addressed in the CMS report.	The iodine-129 and tritium studies will support this operable unit. Work in the 100 Area on nitrate, chromium, and strontium-90 will also be referenced in the 200-PO-1 CMS.
Can the work plan be replaced by an RFI report?	1, 2, 3, 4	The DQO participants determined that the data were sufficient to support preparation of an RFI report and that at this time, additional data collection is not warranted.	

Table A-2 Step 3 - Inputs (page 1 of 3)

INFORMATION COLLECTED IN PREPARATION FOR AND DURING 200-PO-1 DQO PROCESS		
INFORMATION TYPE	**INFORMATION USE**	**SOURCE OF INFORMATION**
Regulatory and decision-making framework	Define potential ARARs, determine regulatory requirements to be addressed	TPA, HPPS, RCRA, CERCLA
Location map including important features such as waste sites, TSDs, facilities, landmarks, etc.	Define operable unit boundaries, identify location and physical characteristics of site	AAMSR, WIDS, CADD drawings
Discussion of geology for the operable unit including formations, thicknesses, extent, etc.	Determine affect of geology on contaminant movement	AAMSR, site wide documents and activities, work plans, operable unit specific documents, scoping documents, analogous areas; site geologists and hydrologists; site wide modeling effort
Discussion of hydrogeology and hydrology for operable unit including hydrologic units, conductivities, transmissivities, aquifer test results, etc., include cross sections, water table maps, geologic surface maps, etc.	Determine affect on contaminant movement, provide background of previous information,	AAMSR, well test reports, site wide documents and activities, work plans, scoping documents, operable unit specific documents, analogous areas
Well location list and map	Determine adequacy of well placement for plume identification	WIDS, work plan, annual groundwater monitoring programs; site geologists and hydrologists
Discussion of cultural resources	Identify cultural resources in operable unit that may affect evaluation of operable unit actions	Cultural resources lab and their documents
Discussion of ecological resources in or affected by operable unit	Identify ecological resources that may impact evaluation of operable unit	Various ecological documents, work plans
Discussion of process knowledge	Aid in evaluating quality and representativeness of existing data	Work plans, AAMSR, scoping documents, knowledgeable employees, site historian
Identification and current status of waste units and operations including brief summary of physical characteristics, waste types and volumes received, operational history	Provide background of operations and characteristics	AAMSR, work plans, scoping documents, site historian
List of constituents analyzed for in operable unit	Aid in evaluating quality and representativeness of existing data	HEIS

Table A-2 Step 3 - Inputs (page 2 of 3)

INFORMATION COLLECTED IN PREPARATION FOR AND DURING 200-PO-1 DQO PROCESS		
INFORMATION TYPE	**INFORMATION USE**	**SOURCE OF INFORMATION**
Data summary of all constituents which were detected in operable unit, include number of samples, number of hits, maximum, minimum, and average concentrations, background concentrations, regulatory levels of concern (Table A-3)	Aid in evaluating quality, quantity, and representativeness of existing data	HEIS; 10 years of data were reviewed and evaluated; data from 204 wells were reviewed
Evaluation of contaminants of potential concern	Aid in determining most important constituents	HEIS; data summary table
Plume maps	Provide visual representation of contamination and aid in determining adequacy of existing data	HEIS, site geology/hydrology personnel
List of potential regulatory limits	Aid in defining contaminants of potential concern	Regulatory support group
NEPA and NRDA considerations, include potential problems, other work, assessment of need for this information in document type	Determine need for and incorporation of these values	Regulatory support group
List of potential remedial action alternatives	Aid in determining contaminants of potential concern, provide summary of available technologies and their status	Other feasibility studies, site treatability studies, national information, EPA and other technology databases
Evaluation of risk associated with operable unit, include potential pathways, conceptual model, affected receptors, calculated risk levels; also discuss logic associated with risk; risks inherent in contaminants including ecological risks	Identify potential risks associated with operable unit, aid in evaluating quality and quantity of existing data and need for additional data	Other work plans, LFIs, QRAs, RI/FS reports, HSRAM, Risk-based decision logic
Identification and evaluation of potential data gaps (those currently known; others were developed as part of DQO process), include case by case summary of information available to fill data gap including analogous site information, extrapolations of information, etc.	Evaluate need for additional data	AAMSR, scoping documents, work plans, other similar areas, geological and hydrological tests and reports, knowledgeable personnel
Modeling results if available, include a summary of inputs and assumptions	Evaluate need for additional data, aid in evaluating adequacy of existing information	Modeling group, modeling reports
Summary of other projects currently being conducted which may impact operable unit such as companion documents, new treatment facilities, etc.	Aid in determining need for additional information and adequacy of existing information	Project managers, TPA milestones, knowledgeable personnel

Table A-2 Step 3 - Inputs (page 3 of 3)

INFORMATION COLLECTED IN PREPARATION FOR AND DURING 200-PO-1 DQO PROCESS		
INFORMATION TYPE	**INFORMATION USE**	**SOURCE OF INFORMATION**
Current status of monitoring, include wells, analytes, frequency, monitoring program	Aid in determining need for additional information and adequacy of existing information	Annual monitoring reports such as environmental report from PNL and RCRA and other groundwater monitoring reports
Time versus concentration plots for groundwater constituents above regulatory limits, include both filtered and unfiltered plots (Figure A-2)	Aid in determining adequacy of existing information, determine contaminants of potential concern, qualitatively estimate risk of plume movement, identify trends in concentration levels	HEIS
Trend plots for individual wells which exceeded regulatory limits	Aid in determining adequacy of existing information, determine contaminants of potential concern, qualitatively estimate risk of plume movement, identify trends in concentration levels	HEIS
Statistical analysis of data, if practical	Aid in determining adequacy of existing information	Site statisticians reviewed and evaluated data; their opinion was that the data are sufficient and additional statistical analysis are not necessary; they felt the trend analysis was an appropriate method of data evaluation for this operable unit

Table A-3. Data Summary Table (page 1 of 6)

Constituent	Number of Samples	Number of Detects	Notes	Maximum Concentration	Minimum Concentration	Average Concentration	Background	MCL
1,1,1-Trichloroethane	406	1	infrequent detect					200
2,4-Dichlorophenol	567	1	infrequent detect					70
2,4-Dichlorophenoxyacetic acid	563	6	infrequent detect					
2,4-Dimethylphenol	450	6	infrequent detect					
2,4-Dinitrophenol	496	2	infrequent detect					
2-Butanone	401	6	infrequent detect					
2-Methylphenol	125	1	infrequent detect					
2-Nitrophenol	488	2	infrequent detect					
2-Propanol	23	2	infrequent detect					
2-secButyl-4,5-dinitrophenol (DNBP)	705	1	infrequent detect					
4,4'-DDD	347	5	infrequent detect					
4,4'-DDE	344	2	infrequent detect					
4,4'-DDT	350	8	infrequent detect					
Acetone	315	20	infrequent detect					
Aldrin	347	5	infrequent detect					
Alkalinity	106	106	< BG	160,000	66,000	92,283	210,000 ppb	
Aluminum	1467	97		14,000	20	1047	<200 ppb	
Americium-241	25	8	< MCL	0.03	0.00	0.02		17
Ammonia	309	34		600	20	125.29		
Ammonium ion	315	34		320	52	105.67	120 ppb	
Antimony-125	242	63	< MCL	23.1	0.35	8.05		242
Arsenic	1379	1167	< BG, < MCL	556	2.5	9.65	10 ppb	50
Arsenic, filtered	437	332	< BG, < MCL	34	5	9.35	10 ppb	50
Barium	2086	1807	< BG, < MCL	343	6.0	39.93	68.5	2000

Table A-3. Data Summary Table (page 2 of 6)

Constituent	Number of Samples	Number of Detects	Notes	Maximum Concentration	Minimum Concentration	Average Concentration	Background	MCL
Benzene	349	1	infrequent detect					5
Beryllium	1763	37	infrequent detect				<5	4
Beryllium-7	35	15	< MCL	2520	4.64	188.57		4848
Bicarbonate	5	5		210,000	22,000	168,400		
Bis(2-ethylhexyl) phthalate	204	12	infrequent detect					
Boron	587	523	< BG	115	10	20.84	<100	
Bromide	802	4	infrequent detect					
Cadmium	1783	36	infrequent detect				<10	5
Calcium (202)	2242	2242		101,000	7,500	30,407	63,600	
Calcium (7440-70-9)	11	11		110,000	41,000	71,727	63,600	
Carbon-14	23	14	< MCL	58.8	4.86	33.96		1939
Cerium/Praseodymium-144	35	17	< MCL	88	0.72	14.75		24
Cesium-134	36	8	< MCL	3.65	0.08	1.69		65
Cesium-137	3616	2429		29,000	0	473.96		121
Chloride	1241	1241		33,000	340	5000	8690/28500	
Chloroform	389	5	infrequent detect					
Chromium	1956	869		3,500	10	119.42		100
Cobalt	1475	7	infrequent detect					
Cobalt-60	2704	1575	High hits in 1950's	440,000	0	523.76		121
Coliform	219	16		2400	202	194.81		
Conductivity	3231	3227	< BG	1256	3.09	303.32	530	
Copper	1826	151		4500	2	57.55	<30	
Di-n-butylphthalate	130	2	infrequent detect					
Dieldrin	347	5	infrequent detect					

Table A-3. Data Summary Table (page 3 of 6)

Constituent	Number of Samples	Number of Detects	Notes	Maximum Concentration	Minimum Concentration	Average Concentration	Background	MCL
Diethyphthalate	131	1	infrequent detect					
Dimethoate	127	5	infrequent detect					
Diphenylamine	128	15		2.86	1.7	2.32		
Dissolved oxygen	8	8		8800	8710	8816		
Endrin	577	5	infrequent detect					2
Endrin aldehyde	274	5	infrequent detect					
Ethyl cyanide	185	1	infrequent detect					
Ethybenzene	95	1	infrequent detect					
Europium-154	35	11	< MCL	11.9	0.4	5.17		48
Europium-155	41	14	< MCL	6.01	0.51	2.67		485
Fluoride	1274	981	< BG	1800	100	534	1340/775	
Gamma-BHC (Lindane)	577	6	infrequent detect					0.2
Gross alpha	1880	1639	< MCL	114	0.12	3.65	63/5.79	
Gross beta	8437	8325		28,000,000	0.24	66,525.65	35.5/12.62	
Heptachlor	347	7	infrequent detect					0.4
Hydrazine	408	2	infrequent detect					
Iodine-129	261	236		1280	0.02	11.69		21
Iodine-129	75	63		26.6	0.05	2.66		
Iodine-129, low level	52	51		11.8	0.09	6.12		
Iron	2170	1694		592,000	10	1714.54	86/291/818	
Lead	940	164	approx. BG	70	0.6	5.9	<5	
Lead-212	3	3	< MCL	10.3	9.56	9.87		194
Lithium	583	23	infrequent detect					
m-Cresol	123	91		6.3	1.44	3.59		

Table A-3. Data Summary Table (page 4 of 6)

Constituent	Number of Samples	Number of Detects	Notes	Maximum Concentration	Minimum Concentration	Average Concentration	Background	MCL
Magnesium	2230	2230	< BG	30,000	870	8746	16480	
Manganese	1924	854		6240	1.9	81.77	24.5/163.5	
Mercury	867	13	infrequent detect				<0.1	2
Methylenechloride	398	34	infrequent detect					
Nickel	1893	683	< MCL	1800	10	69.4	<30	100
Nitrate	2654	2563		1,800,000	32	58175	12,400	10,000
Nitrate	59	59		68,000	880	18,499	12,400	10,000
Nitrate	1224	1107		555,000	200	45,656	12,400	10.000
Nitrate	674	638		572,000	500	67,858	12,400	10,000
Nitrite	1224	84	< MCL	2500	300	850		1,000
Organic	33	33		2500	100	551.52		
Phenol	874	4	infrequent detect					
Phorate	67	1	infrequent detect					
Phosphate	920	11	infrequent detect					
Plutonium	45	45		220	110	127.11		
Plutonium-238	181	13	< MCL	0.02	0.00	0.01		12
Plutonium-239/240	181	23	< MCL	0.44	0.00	0.03		12
Polychlorodibenzodioxin	9	1		0.06				
Polychlorodibenzofuran	9	1		0.03				
Potassium	2250	2250	< BG	14,400	1400	5299.11	7975	
Potassium-40	11	9		101	22.4	51.1		
Potassium-40	24	24		226	7.67	138.95		
Radium	789	310	= BG	2.15	0	0.23	0.23	
Radium-226	1	1		2.31	2.31	2.31		

Table A-3. Data Summary Table (page 5 of 6)

Constituent	Number of Samples	Number of Detects	Notes	Maximum Concentration	Minimum Concentration	Average Concentration	Background	MCL
Ruthenium-106	2013	838	< 1 YR half life	140,000	0.04	1662.45		
Selenium	128	15	< MCL	10.7	3.1	6.77	<5	50
Selenium	1040	17	infrequent detect	48.6	5	9.55		
Silica	4	4		72,000	49,000	66,250		
Silicon	584	584	< BG	73,600	836	17467.7	26500	
Silver	1782	4	infrequent detect	6.4	4.1	5.35	<10	
Sodium	250	250	< BG	180,000	7000	31600	33500	
Sodium	2245	2245		107000	2600	18531.55		
Specific conductance	1349	1349		1994	0.37	333.3		
Strontium	870	803	< BG	522	78	174.76	264.1	
Strontium	1	1		190	190	190		
Strontium-90	3490	2826		1200000	0	1272.22		8
Styrene	93	4	infrequent detect					
Sulfate	1237	1237	< BG	306000	3400	30359.74	90500	
Sulfate	16	16	< BG	84000	30000	60375	90500	
Technetium-99	318	240	< MCL	755	0.1	42.03		1939
Tetrachlorophenol	365	1	infrequent detect					
Tin	1312	5	infrequent detect					
Titanium	583	6	infrequent detect					
Toluene	353	8	infrequent detect					
Total carbon	405	405		41100	11500	23121.98		
Total cresols	446	1	infrequent detect					
Trichloroethene	406	2	infrequent detect					5
Trichloromonofluoromethane	186	1	infrequent detect					

Table A-3. Data Summary Table (page 6 of 6)

Constituent	Number of Samples	Number of Detects	Notes	Maximum Concentration	Minimum Concentration	Average Concentration	Background	MCL
Tris-2-chhloroethyl phosphate	98	5	infrequent detect					
Tritium	3842	3607		67,000,000	1.04	1028280		20000
Uranium	681	676		405	0.01	8.27	3.43	
Uranium-234	76	76	< MCL	15.2	0.21	2.2		73
Uranium-235	76	64	< MCL	0.58	0.02	0.1		1212
Uranium-238	76	76	< MCL	15.4	0.18	2.05		145
Vanadium	1936	1412		656	5	34.91	15	
Xylenes (total)	382	2	infrequent detect					
Zinc	1935	956	< BG	1000	3.2	26.2	<50/673	
Zinc-65	35	12	< MCL	23.5	0.84	5.23		727
Zirconium/Niobium-95	35	12	< MCL	421	1.86	39.87		145

Table A-4. Risk Assessment Strategy for CMS Report

AREA	RISK AT TIME BOUNDARIES		
	Current Year	**Year 2018 (Final operable unit remedial actions)**	**Year 2128 (closing single shell tanks plus 100 years)**
On Plateau	Industrial Risk	Industrial Risk	Residential Risk
Off Plateau	Industrial Risk	Residential Risk Agricultural Risk from Irrigation Ecological Risk	Residential Risk Ecological Risk
River	Recreational Risk Ecological Risk	Recreational Risk Ecological Risk	Recreational Risk Ecological Risk
Potential Resulting Action	IRM	IRM	Final RFI/CMS

Table A-5 Step 5 - Decision Rules and Step 6 - Decision Uncertainties

Decision Point	Decision Rule	Decision Uncertainty
Should filtered or unfiltered data be used for inorganics?	If turbidity is greater than or equal to 5, then use filtered data for inorganics. Use filtered data for chromium.	Turbidity data is limited; therefore, increasing the uncertainty associated with the application of the decision rule. The filtered data for chromium are indicative of hexavalent chromium; however, total chromium is generally the only available data. An assumption that all chromium is hexavalent results in some uncertainty; however, the levels and extent of chromium are limited in the operable unit and are not impacting the river.
What level to use to identify contaminants of concern if the MTCA values are less than background?	If MTCA is less than background, then use the background value for screening contaminants.	Hoover and LeGore (199?) represent the most current background values. The regulators have concerns with this document and would like to review the contaminant screening when complete to discuss the screening and background values used.
How should MCLs and MTCA levels be applied to the operable unit?	If the contaminants are confined to the plateau, use MTCA C if available; otherwise use MCLs. If neither are available, then use background values. If contaminants are off the plateau or have significant potential to migrate off plateau at levels of concern, use MTCA B values; otherwise use MCLs. Use background if neither of these values are available.	Uncertainties include the background values and the migration of contaminants. The background values will be individually discussed with the regulators and DOE. The migration of contaminants will be assessed through the modeling for the site wide groundwater strategy document.
How should data be screened to determine contaminants of concern?	Use the flowchart with the decision points and rules that was developed as part of the DQO process.	See Figure 3-2. Lack of background and turbidity data introduces some uncertainty.
Should ruthenium-106 continue as an analyte for the operable unit?	Gross beta values will continue to be monitored. If gross beta values are elevated, then analyze for ruthenium-106.	Ruthenium-106 has a short half-life.
How should source terms be considered?	If contaminants are screened from the operable unit as a whole, they should be considered as potential contaminants associated with specific TSD units. The impacts of these TSD will be considered in the RFI. The monitoring evaluation will consider potential analytes to address both operable unit and TSD monitoring needs	Because the groundwater RFI/CMS process is ahead of the process for the source operable units, some uncertainty exists concerning contribution from soils to the groundwater. The source operable units will have to consider this aspect and there will be coordination between the groundwater and source operable unit remediations.
Are alternate concentration levels (ACL) required?	If technical impracticability, including cost, is demonstrated, then ACLs should be considered.	This evaluation will be part of the CMS and supporting documents. Treatability information is limited for tritium and iodine-129.
What are the monitoring requirements and how will they be integrated with other programs?	If wastes are left in place, then RCRA groundwater monitoring requirements will be applicable.	The RFI will evaluate current monitoring programs and provide an assessment of integration between operable unit requirements and those of the other programs.

Table A-6 200-PO-1 RFI Report Outline (page 1 of 2)

EXECUTIVE SUMMARY

1.0 INTRODUCTION

1.1 Purpose and Scope

Discuss decision making process (i.e. RCRA past practice process and HPPS). Discuss documentation strategy, i.e. straight to RFI report since no work was required. Discuss use of the report to support future decisions.

1.2 Operable Unit Background

1.2.1 OU Description

Discuss location of OU and relationship to other OUs and the Hanford Site.

1.2.2 OU History

Discuss process knowledge and operational history.

1.3 Report Organization

2.0 OPERABLE UNIT INVESTIGATIONS

2.1 Summary of Previous Investigations

Describe previous and existing monitoring programs and summarize "what has been done" at the operable unit. Incorporate by reference as much as possible.

3.0 PHYSICAL CHARACTERISTICS

Discuss the elements listed below as summaries of existing documentation where applicable.

3.1 Surface Features

3.2 Meteorology

3.3 Surface-Water Hydrology

3.4 Geology

3.5 Soils

3.6 Hydrogeology

3.7 Demography and Land Use

3.8 Ecology

4.0 NATURE AND EXTENT OF CONTAMINATION

4.1 Sources of Contamination (Process Knowledge of Waste Sites)

4.2 Potential to Impact Groundwater

Identify those sites which disposed of a volume which may impact groundwater. Identify potential groundwater contaminants.

4.3 Identification of Contaminants of Interest

Describe screening methodology to identify the COI

4.4 Well-Specific Data Trending

Provide trend analysis for each of the COI

Table A-6 200-PO-1 RFI Report Outline (page 2 of 2)

4.5 Definition of Contaminant Plumes
Provide plume maps for the COI and discuss the rationale for their generation.

5.0 RISK EVALUATION
Define the Contaminants of Potential Concern (COPC). Describe exposure scenarios, receptors, etc.. Qualitative discussion of potential ecological risks. Present contaminant transport over time.

6.0 SUMMARY AND CONCLUSIONS
6.1 Summary of data evaluation and risk assessment. Re-iterate COPC.
6.2 Remediation Approach
Identify the appropriate decision pathway (i.e. ERA, IRM, LFI, Final RI/FS) pathways for addressing the COPC.
6.3 Potential Remedial Actions
Identify potential remedies for the COPC to provide a link to future FS activities, including a proposed schedule.
6.4 Need for Additional Investigations/Monitoring
Identify any data gaps or additional data needs to support current and future decisions (e.g. Is a treatability study needed to support the FS?, Do we need a Phase II RI?) Identify a minimum monitoring plan to support the operable unit considering all the current monitoring programs in place.

APPENDICES
Appendix A - Well-Specific Trend Analysis
Appendix B - DQO Process

APPENDIX B

GEOLOGIC CROSS SECTIONS

Figure B-1. Generalized Geologic Map of the Hanford Site

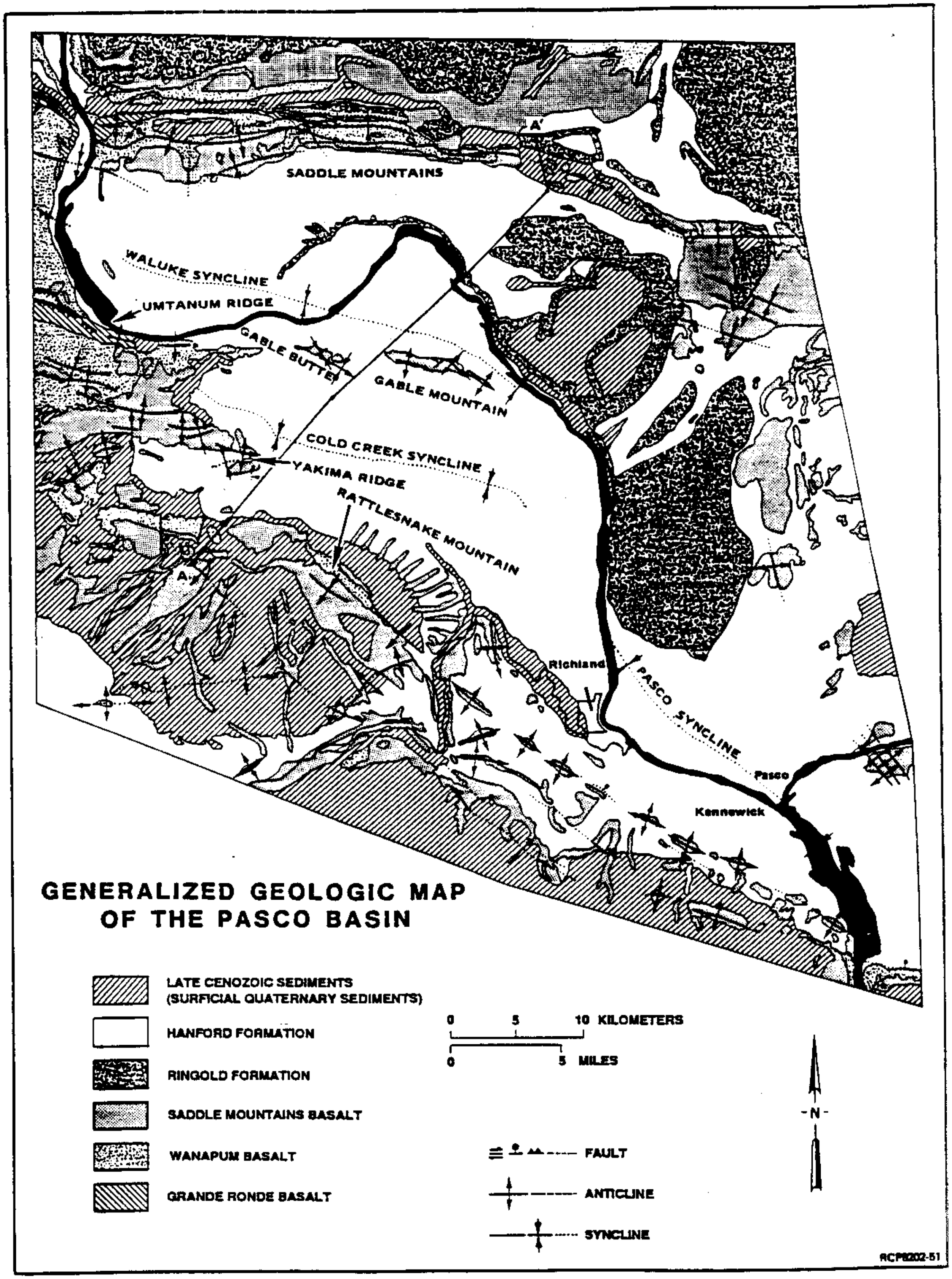


Figure B-2. Late Neogene Stratigraphy of the Pasco Basin Emphasizing the Ringold Formation

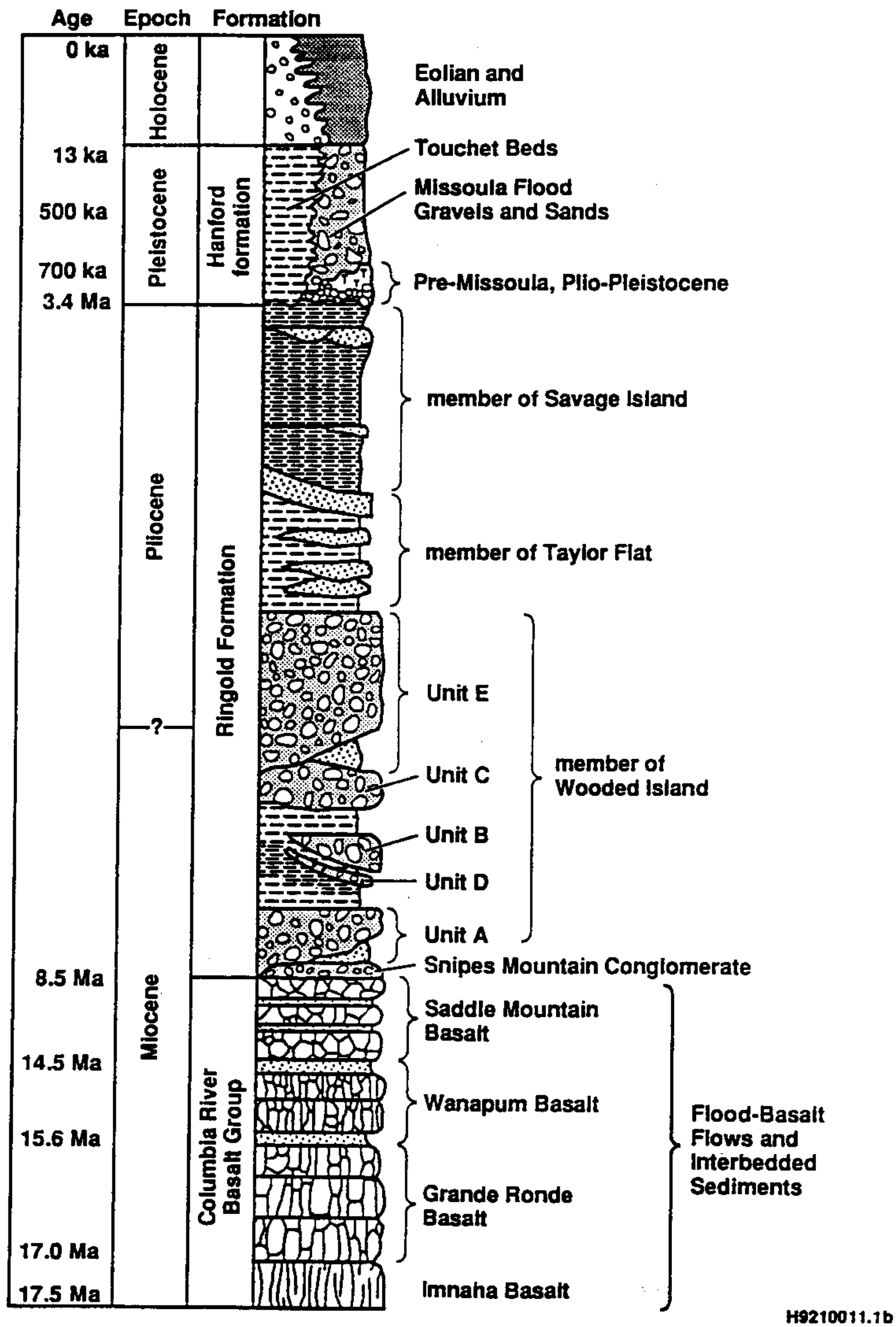
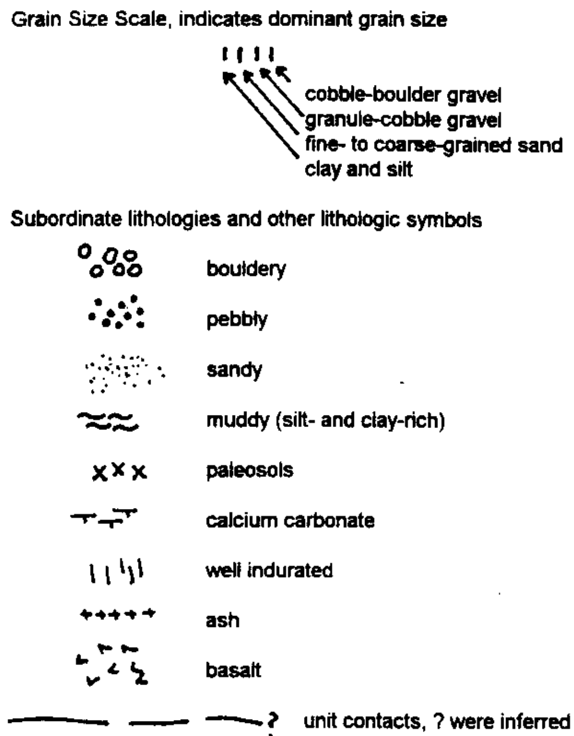


Figure B-3. Explanation of Symbols and Abbreviations used in Cross Sections

Locations of cross sections are shown on inset maps of the Hanford Site on each cross-section page.

EXPLANATION OF SYMBOLS AND ABBREVIATIONS USED IN CROSS SECTIONS



Stratigraphic unit abbreviations

PM - pre-Missoula gravel of Plio-Pleistocene interval

UR - upper Ringold, Ringold Formation member of Taylor Flat

E - unit E, Ringold Formation member of Wooded Island

C - unit C, Ringold Formation member of Wooded Island

B - unit B, Ringold Formation member of Wooded Island

D - unit D, Ringold Formation member of Wooded Island

LM - lower mud unit, Ringold Formation member of Wooded Island

A - unit A, Ringold Formation member of Wooded Island

Figure B-4. Generalized Geologic Cross-Sections of the Hanford Site E-E'

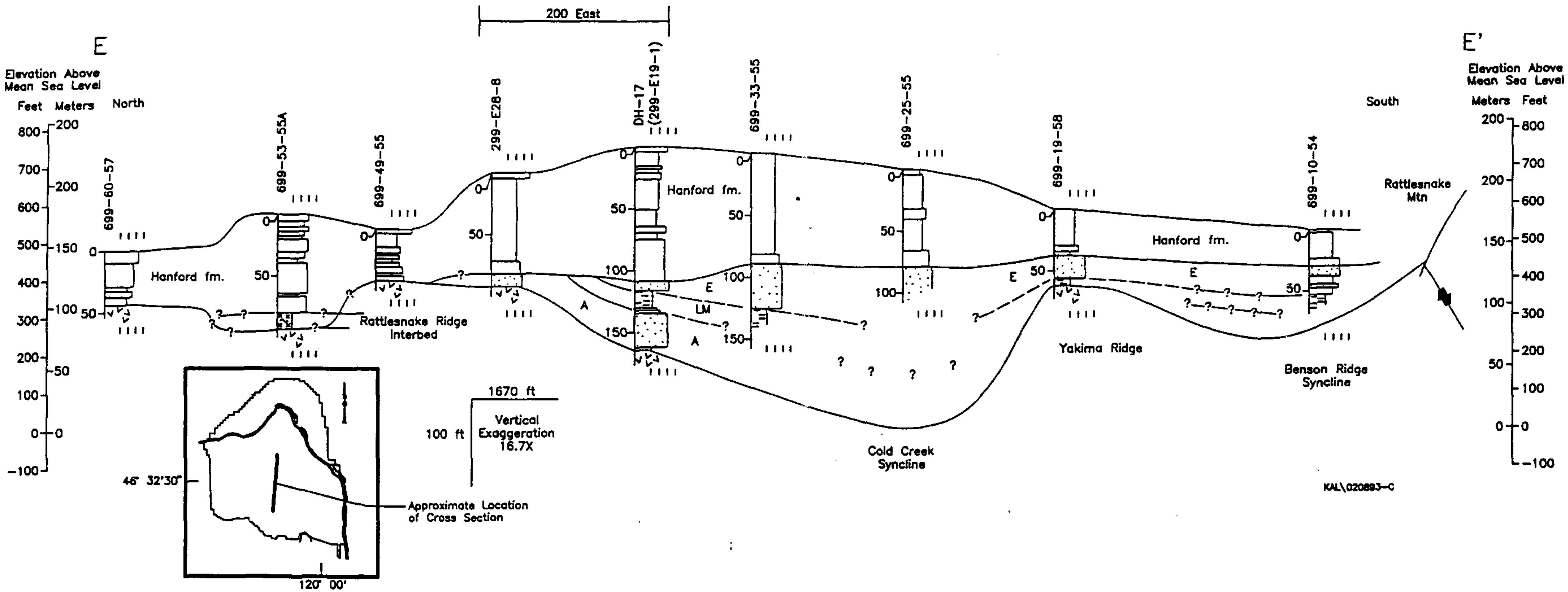


Figure B-5. Generalized Geologic Cross-Sections of the Hanford Site F-F'

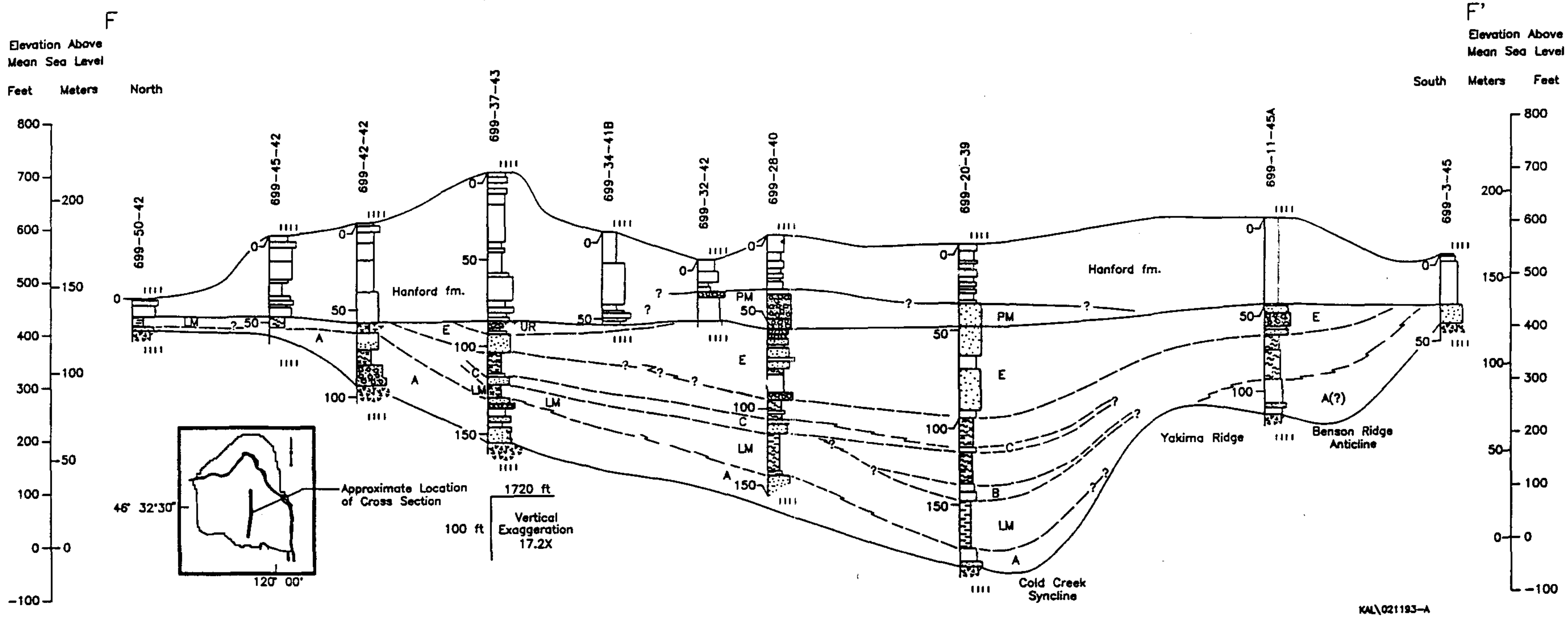


Figure B-6. Generalized Geologic Cross-Sections of the Hanford Site

G-G'

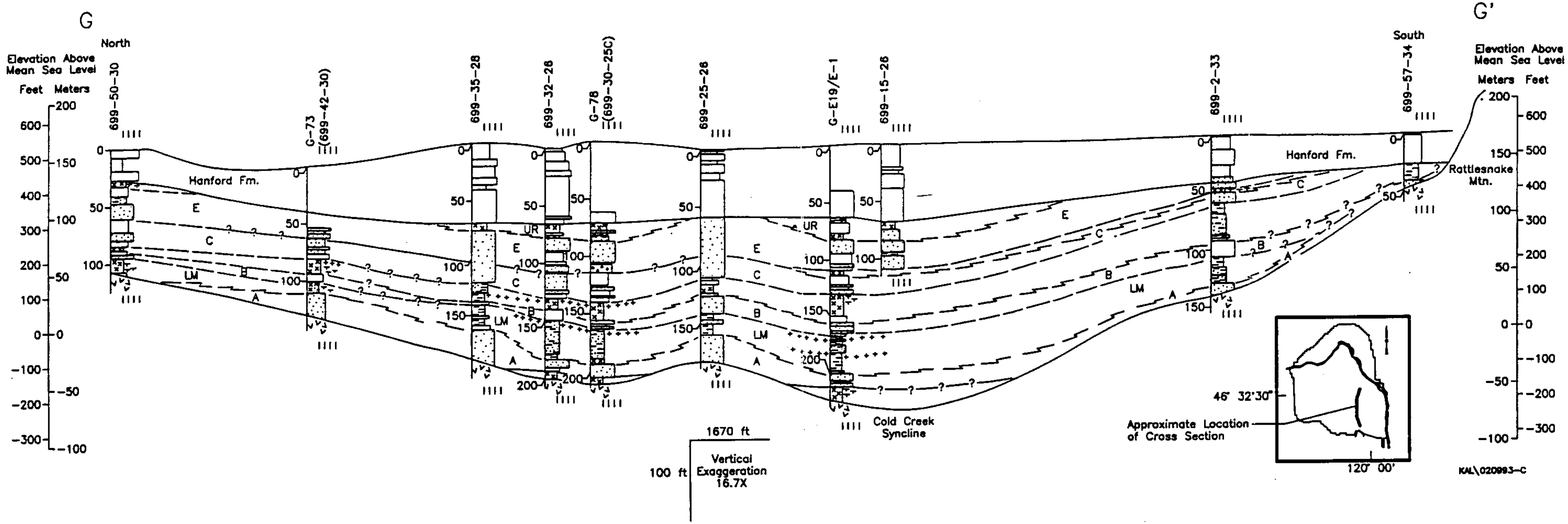


Figure B-7. Generalized Geologic Cross-Sections of the Hanford Site I-I'

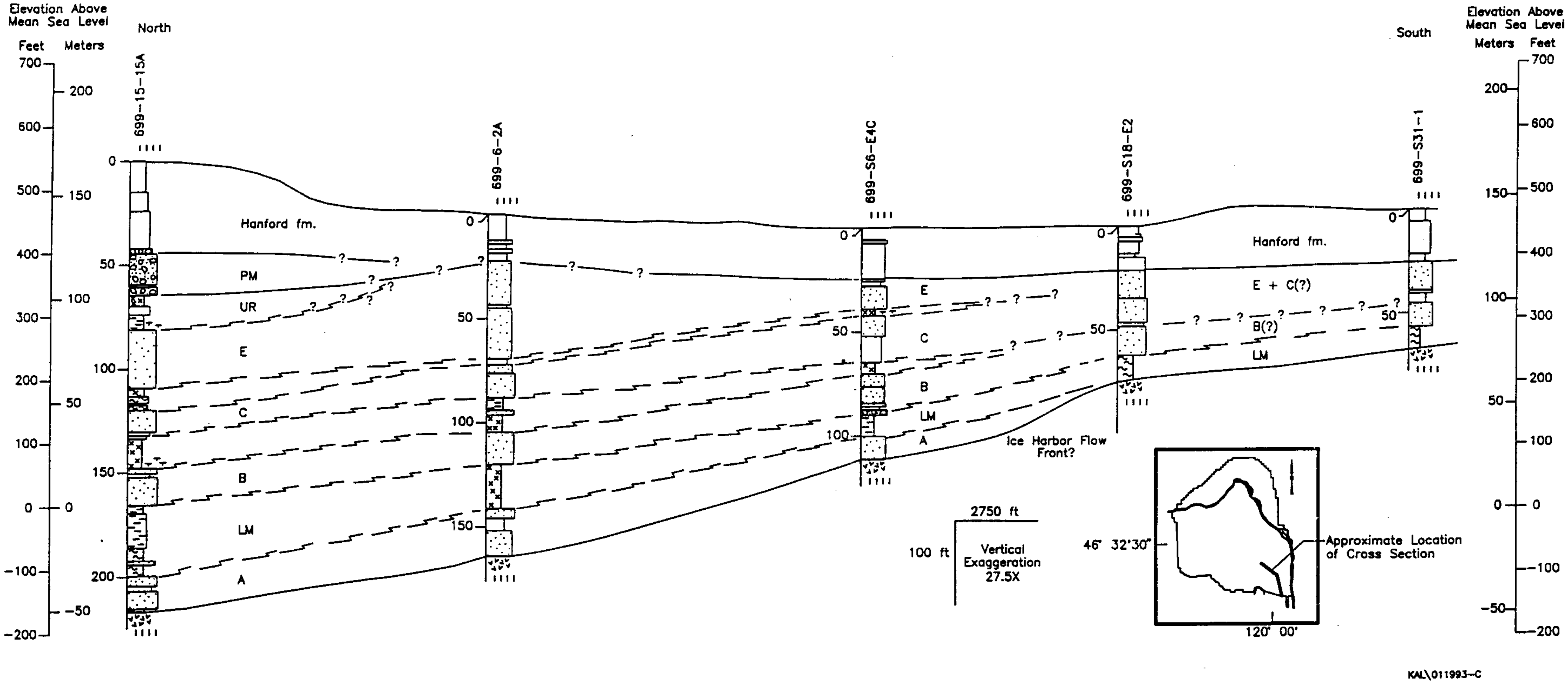


Figure B-8. Generalized Geologic Cross-Sections of the Hanford Site J-J'

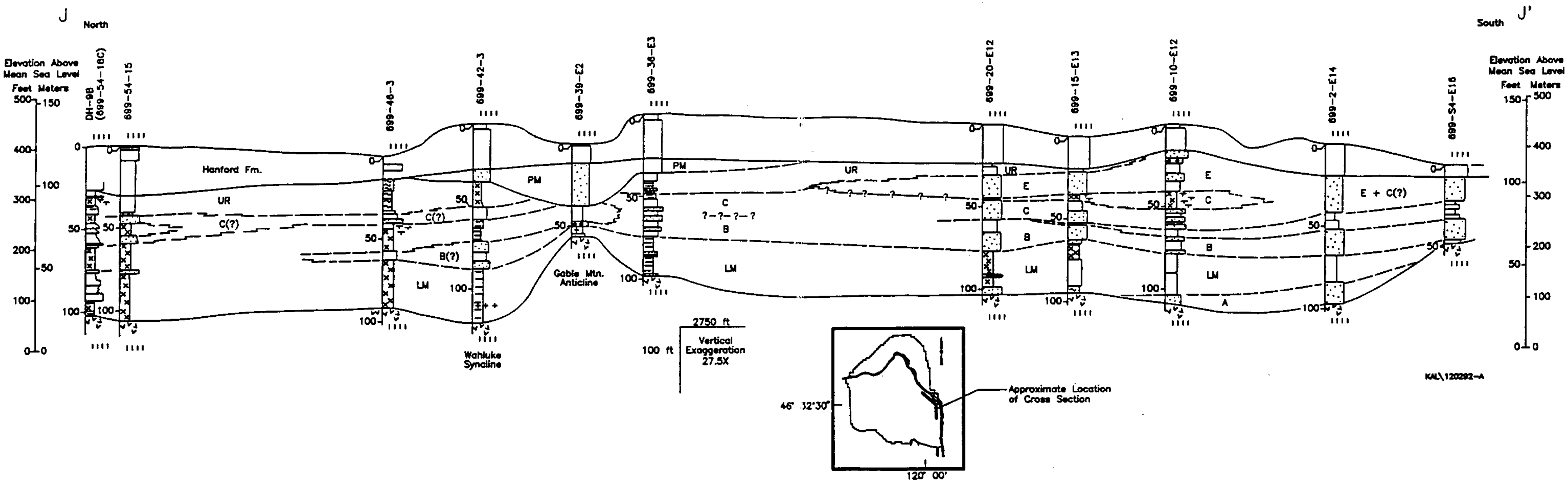


Figure B-9. Generalized Geologic Cross-Sections of the Hanford Site
O-O'

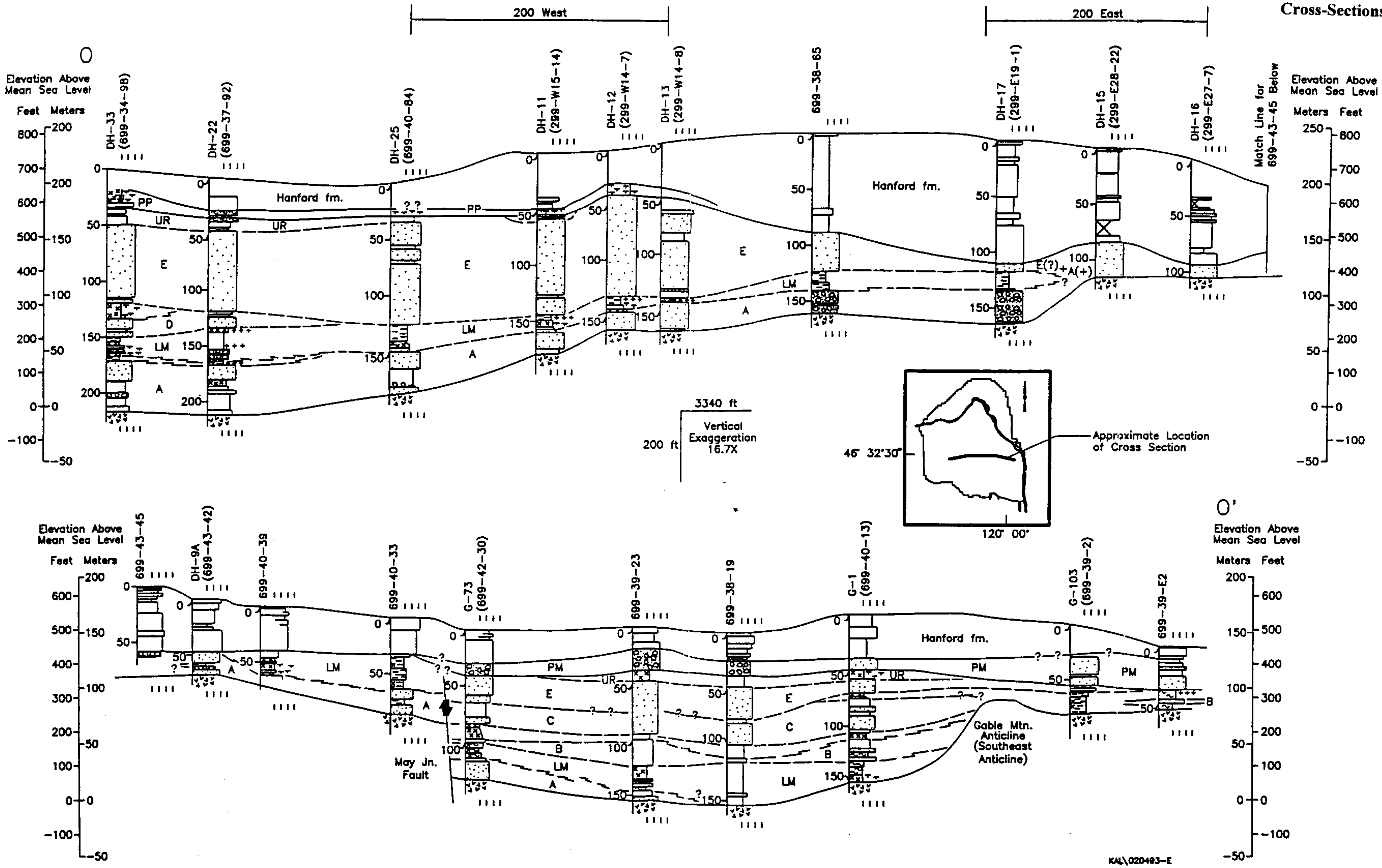


Figure B-10. Generalized Geologic Cross-Sections of the Hanford Site P-P'

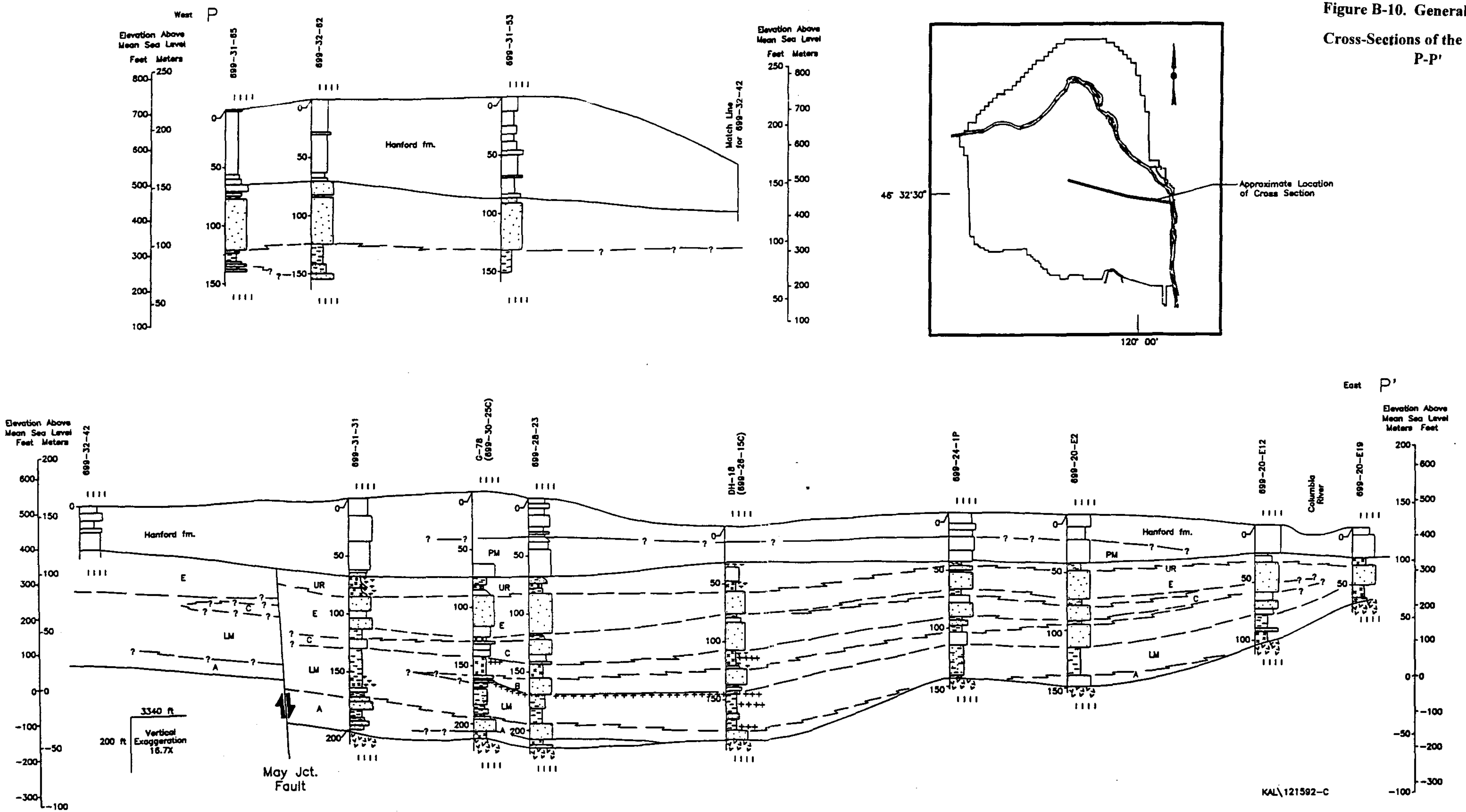


Figure B-11. Generalized Geologic Cross-Sections of the Hanford Site
Q-Q'

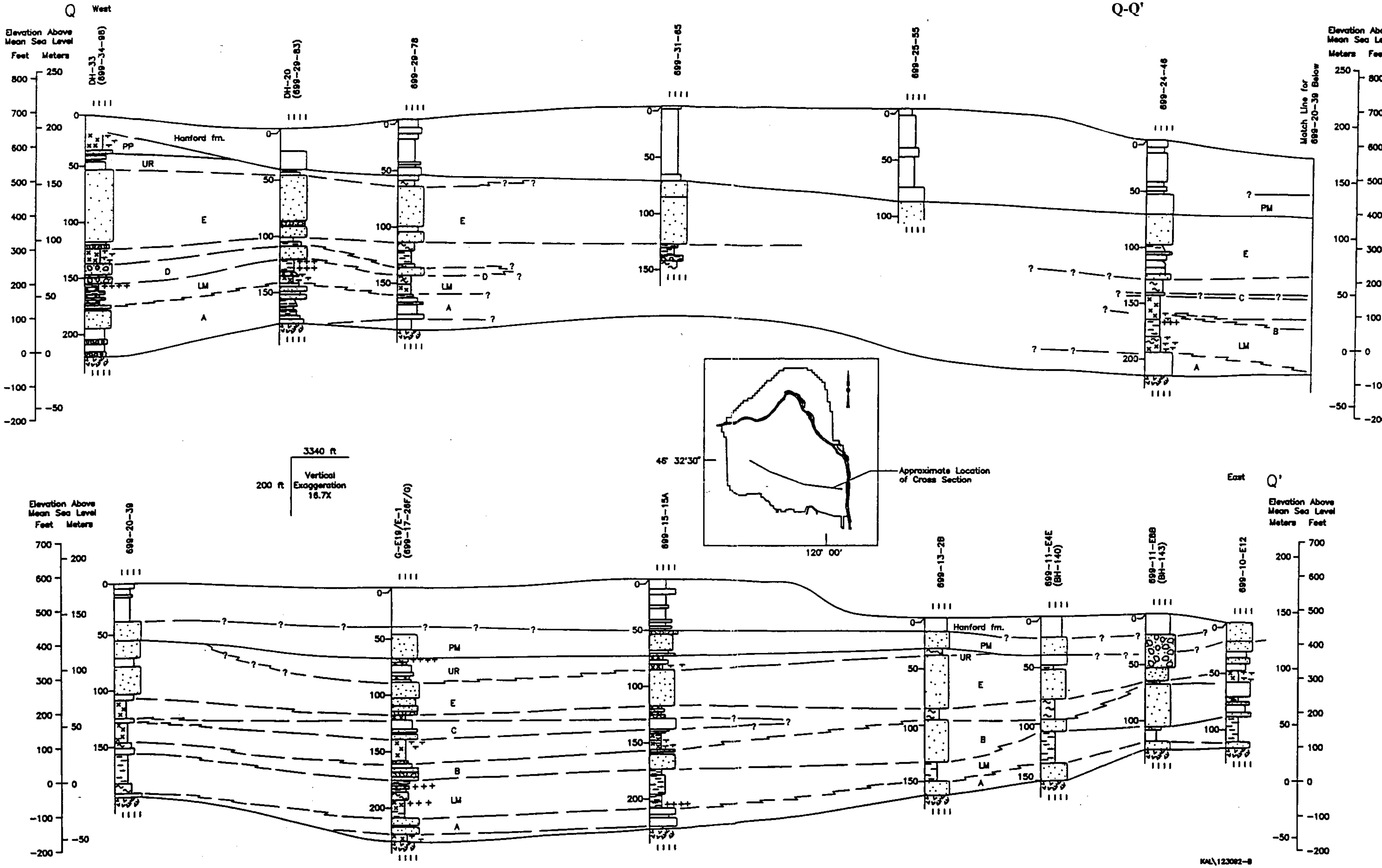
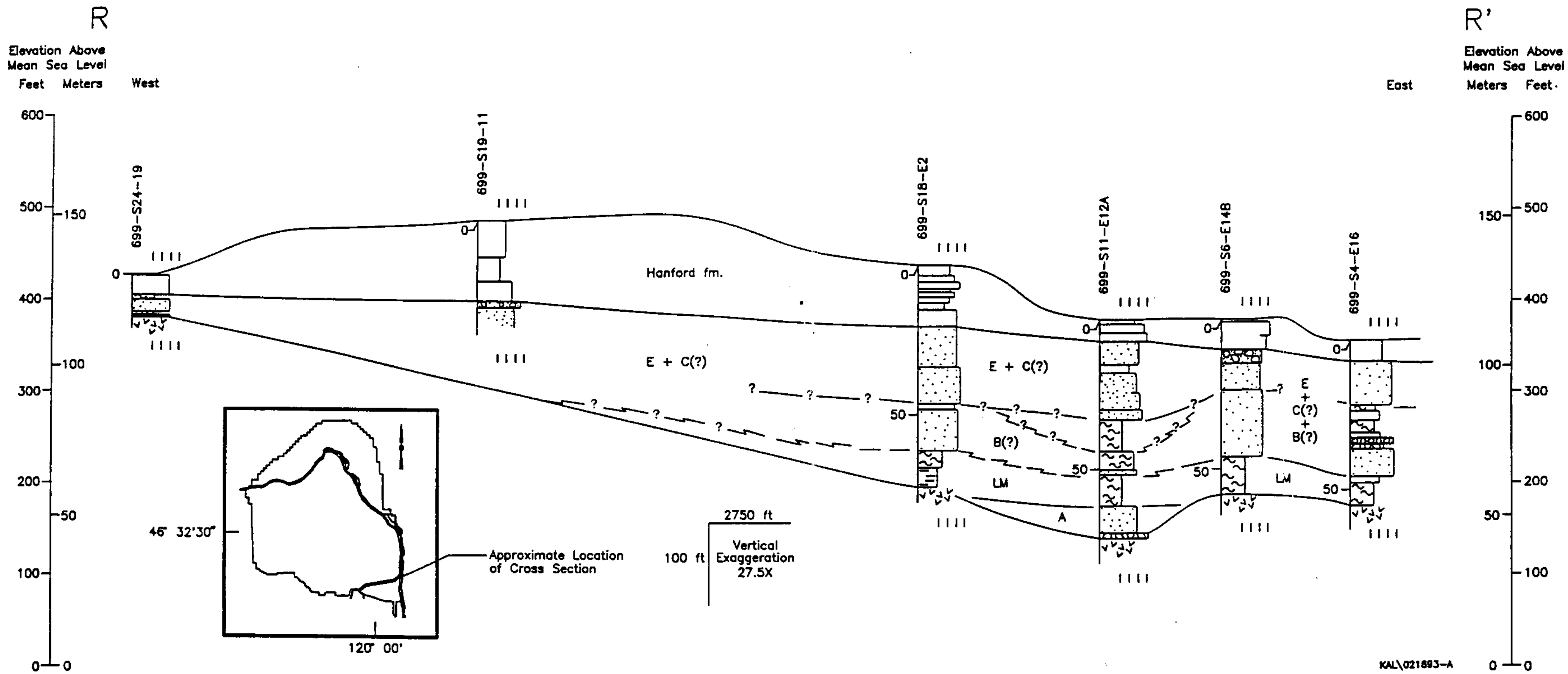


Figure B-12. Generalized Geolog Cross-Sections of the Hanford Site R-R'



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